Tektronix®

OF235 FIBER OPTIC TIME DOMAIN REFLECTOMETER

OPERATOR MANUAL

INSTRUCTION MANUAL

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LIST OF ILLUSTRATIONS

OPERATOR SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

Terms

In This Manual

CAUTION statements identify conditions or practices which could result in damage to the equipment or other property.

WARNING statements identify conditions or practices which could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols

In This Manual

⚠ This symbol indicates, where applicable, cautionary or other information is to be found.

As Marked on Equipment

DANGER—High Voltage

ATTENTION—refer to manual.

Protective ground (earth) terminal.

Power Source

This product is intended to operate from a power source that will not apply more than 250 volts RMS between the supply conductors or between the supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that appear to be insulating) can render an electric shock.

Use the Proper Power Cord

Use only the power cord and connector specified for your product.

Use only a power cord that is in good condition.

Refer cord and connector changes to qualified service personnel.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of the correct type, voltage rating, and current rating as specified in the parts list for your product.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

Optical Output

Avoid eye exposure to the output of open-ended fibers by covering the end or directing the output at a non-reflective surface.

GENERAL INFORMATION AND SPECIFICATION

General Information

Product Description

The TEKTRONIX OF235 Time Domain Reflectometer is an optical fiber tester that is capable of measuring loss characteristics, and detecting and locating faults in single-mode fibers.

The OF235 applies a pulse of energy to the fiber to be tested via the OPTICAL OUTPUT connector. When the pulse is traveling through the fiber, some energy is reflected back to the OF235. These reflections are processed and displayed on the cathode ray tube (CRT), where distance and loss measurements can be made using a marker technique.

The CRT display is a time plot that is read from left to right. When viewing a typical fiber display, the reflections appear to the right (later in time). The trace starts with the outgoing pulse, and the time difference is converted to distance in the measurement process.

The OF235's DIST/DIV (distance per division) is calibrated in a 1-2-5 sequence, which allows the horizontal scale on the CRT to show units from 50 meters to more than 100,000 meters. Distance is read out on the liquid crystal display(LCD).

Loss measurements are made on the vertical CRT scale. These measurements can be displayed in 5, 1, or 0.25dB per division. The LCD displays loss when any of the three LOSS MODEs has been selected.

The OF235 display is digitally stored. The waveform on the screen changes only when a new sweep is started.

Three outgoing pulses can be selected: LONG PULSE, MEDIUM PULSE, or SHORT PULSE (for better resolution in some measurements).

The FILTERs use signal averaging to reduce measurement noise.

The OF235 has an optional chart recorder that is useful for documenting fiber conditions.

This instrument may be operated from an AC power source or a 12 V battery.

Battery Pack

The OF235 may be operated from a 12 V battery using the battery power cord. A car battery or a portable battery pack may be used. Portable batteries manufactured by Elpower Corporation of Santa Ana, California or Globe Union, Inc. of Milwaukee, Wisconsin will supply the user with several hours of operating time.

Standards, Documents, and References

Terminology used in the manuals is in accordance with industry practice. Abbreviations are in accordance with ANSI Y1.1-1972, with exceptions and additions explained in parentheses after the abbreviation. Graphic symbology is based on ANSI Y32.2-1975. Logic symbology is based on ANSI Y32.14-1973 and the manufacturer's data books or sheets. A copy of ANSI standards may be obtained from the Institute of Electrical and Electronic Engineers, 345 47th Street, New York, New York 10017.

Change and History Information

Changes that involves manual corrections and/or additional data will be incorporated into the text with a revision date (e.g., REV FEB 1985) located at the bottom inside edge of any changed page. History information with the updated data is integrated into the diagrams in grey when it is updated.

Specification

Table 1-1 lists the electrical characteristics and features that apply to the OF235 after a 15 minute warmup.

The Performance Requirement column describes the limits of the characteristic, and the supplemental column describes features and typical values, or information that may be helpful to you.

Procedures to verify the performance requirements are provided in the Calibration section of the Service Manual. The performance check procedures require sophisticated equipment as well as technical expertise to perform.

The Operating Instructions (Section 3) contain a procedure that checks all functions of the OF235. This check is recommended for incoming inspections to verify that the instrument is performing properly.

Table 1-1
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
	HORIZONTAL DISPLAY	
Distance scales		5 meter/div to 5000 meter/div
Distance range		–25 meters to 99.9 kilometers from front-panel connector for 1300nm, –25m to 99.9km for 1550nm
On-screen distance calibration		1.499 (Index of Refraction)
"Zero" distance reference	±2.0 meters on screen	+5dB point on leading edge of outgoing pulse, referenced to the bottom of displayed noise
Number of stored waveform points		126 (interpolated to 500)

Table 1-1 (cont)
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
VERTICAL DISPLAY		
Vertical scale		5dB/div, 1dB/div, or 0.25dB/div (10 divisions, one-way loss)
dB Scale accuracy	±0.25dB over any 5dB increment from +10dB to +25dB, relative to the bottom of the display range	Measurements are made with the Marker
Incremental dB scale accuracy		Typical ±0.025dB over any 1dB increment from +5dB to +30dB, relative to bottom of display range

Table 1-1 (cont)
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
SIGNAL AND MEASUREMENT CHARACTERISTICS		
⚠ System pulse rate (sampling rate)		1.550kHz, ±1.5Hz @ 1300nm 763Hz, ±1Hz @ 1550nm
Sweep time 1300nm		0.1 second (FILTER OFF) 3 seconds (FILTER MIN) 51 seconds (FILTER MAX)
1550nm (or 1300nm when any point on screen exceeds 60km)		0.2 seconds (FILTER OFF) 6 seconds (FILTER MIN) 102 seconds (FILTER MAX)
⚠ Optical output amplitude	1300nm≥2.5μW 1550nm≥0.59μW	Time average power coupled into test fiber (9μm core, 0.10 NA) (MED PULSE, FILTER MAX)
⚠ Absolute maximum optical output amplitude		50μW time-average power
Optical output wavelength		1300nm, ±30nm 1550nm, ±30nm

Table 1-1 (cont)
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
	PULSE CHARACTERISTICS	
Displayed noise on the incident pulse	≤ 0.5dB RMS (OFF FILTER)	Two-way loss (<1.0 div on screen @ 0.25 dB/DIV
Displayed pulse width * LONG PULSE MEDIUM PULSE SHORT PULSE SHORT PULSE (Opt. 12)	 407 meters, ±20 meters 147 meters, ±12 meters 47 meters, ±4 meters 17meter, ±1.2 meters	 Measured at –3dB from peak amplitude point
Displayed pulse risetime	≤10m from –10dB point to –3dB point	Signal levels referenced to peak amplitude of pulse

*NOTE: * Displayed Pulse width is approximately three meters less than actual pulse width due to bandwidth limitations.*

Table 1-1 (cont)
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Displayed RMS noise floor		FILTER OFF (5dB/div scale) 1.8 divisions from bottom of display range
Decrease in RMS noise floor through filtering		7.5dB (FILTER MIN) (0.75 div @ 5dB) 15dB (FILTER MAX) (1.5 div @ 5dB)
Dynamic range between peak optical output pulse and RMS noise floor (FILTER MAX)		1300nm = 80dB (typical) 1550nm = 77dB (typical)
Maximum one-way fiber loss for ±0.1dB scattering signal measurements (FILTER MAX)		1300nm = 10.5dB (typical) 1550nm = 6.5dB (typical)
Maximum one-way fiber loss for fiber end detection (FILTER MAX)		1300nm = 33dB (typical) 1550nm = 30dB (typical) (assuming 4% Fresnel reflection)
Minimum one-way scattering signal measurement	1300nm ≥17.3dB 1550nm ≥ 13.8dB	For SNR=1.0. Minimum scattering with 4μs pulse width referenced to incident optical power 1300nm ≥ −43.5dB 1550nm ≥ −46.5dB

Table 1-1 (cont)
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
NUMERIC READOUT		
Distance measurements Readout range		0 to 99.9km at 1.499 IR
Readout resolution		1 meter
INDEX OF REFRACTION		1.400 to 1.599
Distance measurement accuracy		±0.05% (±1 meter) ± uncertainty in fiber cal factor
Loss measurements Readout range		−25.00dB to +25.00dB (one-way fiber loss) from center reference point
Readout resolution MAN		0.01dB (0.25dB/div scale) 0.04dB (1dB/div scale) 0.20dB (5dB/div scale)
AUTO		0.01dB
/km		0.01dB

Table 1-1 (cont)
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
OPERATIONAL CHARACTERISTICS		
Power requirements AC operation		90-132VAC or 180-250VAC, 45-440Hz; 28W nominal (45W max)
DC operation		10-16VDC, 24W nominal (33W max)
Laser product safety classification under the Radiation Control for Health and Safety Act of 1968 and BS4803		Class I

Table 1-2
ENVIRONMENTAL CHARACTERISTICS

Characteristic	Description
Temperature	
Operating	–15°C to +55°C
Non-operating	–30° to +70°C
Humidity	95% (+5%,–0%)
Altitude	
Operating	4,600 meters
Non-operating	12,000 meters
Vibration	Frequency swept from 5 to 55 Hz for 25 minutes with 5 minute dwell at 55 Hz in each of four axes, producing peak-to-peak displacement of 0.025 inches
Shock (non-operating)	50 g
Bench handling	4 inches topple, or 45° topple, or point of balance
Transit drop	8 inches
Water resistance	Drip-proof with front cover on
Fungus inert	Materials used are fungus inert

Table 1-2 (cont)
ENVIRONMENTAL CHARACTERISTICS

Characteristic	Description
Electromagnetic compatibility	Within limits described in MIL-STD-461 Complies with VDE 0871B
Conducted emissions	Test methods CE-01 and CE-03
Conducted susceptibility	Test methods CS-01, CS-02, and CS-06
Radiated emissions	Test method RE-02
Radiated susceptibility	Test methods RS-01 and RS-03
Package transit vibration	Tektronix Standard 062-2858-00, paragraph 9.1
Package drop	Tektronix Standard 062-2858-00, paragraph 9.2
Electrostatic Discharge	Tektronix Standard 062-2862-00

NOTE: This instrument meets the specifications of MIL-T-28800B, Type III, Class 3, Style C, with the exception of Radiated Emission Specification RE-01 and non-operating temperature.

Table 1-3
PHYSICAL CHARACTERISTICS

Characteristic	Description
Weight	including standard accessories, except operator's manual, 16.4 kg (36 lbs)
Dimensions without front cover, handle, or feet	17.5 × 32.69 × 49.91 cm 7.0 × 13.07 × 19.96 inches
with front cover, handle, and feet	23.2 × 38.22 × 49.91 cm, handle folded over instrument 23.2 × 38.22 × 73.2 cm, handle fully extended 9.28 × 15.28 × 23.44 inches, handle folded over instrument 9.28 × 15.28 × 29.28 inches, handle fully extended

INSTALLATION AND REPACKING

Unpacking and Initial Inspection

Before unpacking the OF235 from its shipping container or carton, inspect for signs of external damage. If the carton is damaged, notify the carrier. The shipping carton contains the basic instrument and its standard accessories. Refer to the replaceable parts list in the Service Manual for a complete listing.

If the contents of the shipping container are incomplete, if there is mechanical damage or defect, or if the instrument does not meet operational check requirements, contact your local Tektronix Field Office or representative. If the shipping container is damaged, notify the carrier as well as Tektronix.

The instrument was inspected both mechanically and electrically before shipment. It should be free of mechanical damage and meet or exceed all electrical specifications. Procedures to check functional or operational performance are in the Operating Instructions. This check should satisfy the requirements for most receiving or incoming inspections. The electrical performance check procedure is part of the Service Manual.

Preparation for Use

The front cover of the OF235 provides a dust-tight seal. Use the cover to protect the front panel when storing or transporting the instrument. The cover is also used to store accessories. The cover is removed by pulling out on the two release latches. The door to the accessories compartment is unlatched by pressing the latch to the

side and lifting the cover.

The handle of the OF235 can be positioned at several angles to serve as a tilt stand; or it can be positioned at the top rear of the instrument between the feet and the rear panel so OF235 instruments can be stacked. To position the handle, press in at both pivot points and rotate the handle to the desired position.

Power Source and Power Requirements

The OF235 is intended to be operated from a power source that will not apply more than 250V RMS between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

The AC power connector is a three-wide polarized plug with the ground (earth) lead connected directly to the instrument frame to provide electrical shock protection. If the unit is connected to any other power source, the unit frame must be connected to an earth ground.

Power and voltage requirements are printed on the back panel. The OF235 can be operated from either 115VAC or 230VAC nominal line voltage, at 45 to 440Hz; or a 12VDC supply.

Power source selection can be made with switches on the OF235 back panel. When operating at an AC voltage, selection of a HI or LO range within the specified voltage range should be made.

For AC operation, set the range and the HI-LO switches to correspond to the the available line voltage as follows:

115 LO:	90-110VAC
115 HI:	108-132VAC
230 LO:	180-220VAC
230 HI:	216-250VAC

When changing from 115VAC to 230VAC, make sure a fuse of the correct rating is in place.

Repacking for Shipment

When the OF235 is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing the name and address of the owner, name of the individual at your firm that can be contacted, complete serial number, and a description of the service required. If the original packaging is unfit for use or is not available, repackage the instrument as follows:

1. Obtain a carton of corrugated cardboard having inside dimensions that are at least six inches greater than the equipment dimensions to allow for cushioning. The test strength of the shipping carton should be 275 pounds (102.5 kg).
2. Install the front cover on the OF235, and surround the instrument with polyethylene sheeting to protect the finish.
3. Cushion the instrument on all sides with packing material or urethane foam between the carton and the sides of the instrument.
4. Seal with shipping tape or an industrial stapler.

If you have any questions, contact your local Tektronix field office or representative.

OPERATING INSTRUCTIONS

CAUTION

The OF235 has been classified as a Class I Laser Product under the Radiation Control for Health and Safety Act of 1968.

Although output from a Class I laser is not considered hazardous, it is a good practice not to allow eye exposure from direct or reflected laser light. This can be avoided by covering the end of the fiber or directing the output at a non-reflective surface.

It is important that the information in this manual for setting up and operating the instrument be followed.

Controls, Indicators, and Connectors

The function of the controls, indicators, and connectors on the front panel of the OF235 is described below. Figure 3-1 illustrates their locations.

Controls

(1) **POWER**

Pull-type switch which turns the instrument on.

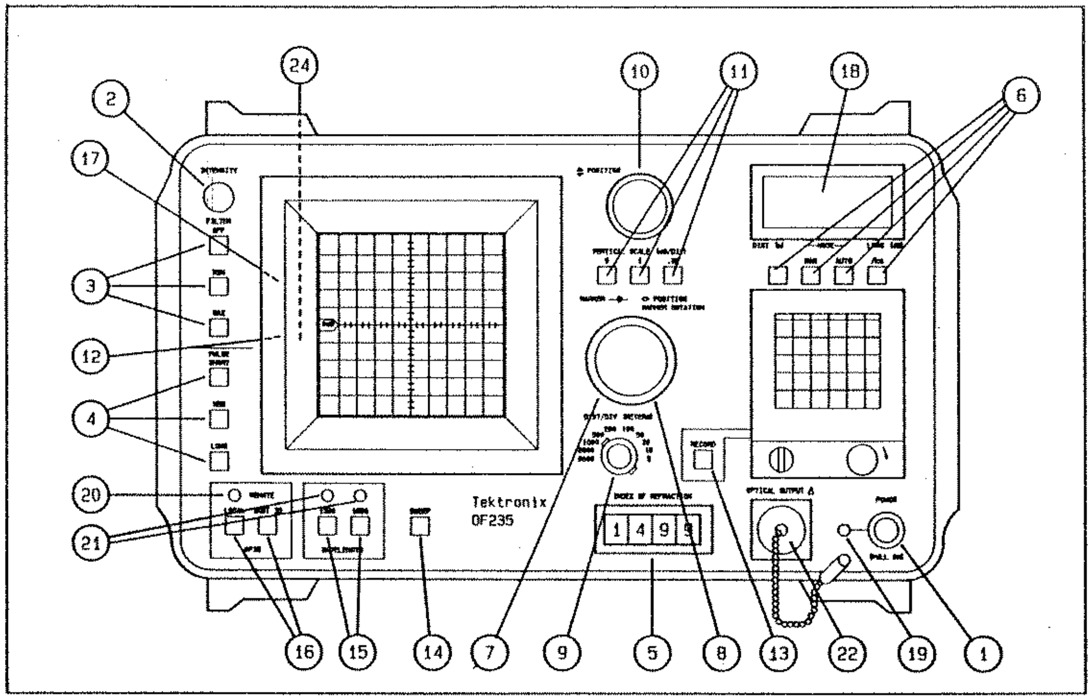


Fig. 3-1. Front-Panel Controls, Indicators, and Connectors.

(2) **INTENSITY**

Controls the brightness of the CRT trace.

(3) **FILTER**[1] (OFF, MINIMUM, MAXIMUM) Provides three degrees of noise reduction and three corresponding averaging times.

Single-Sweep Mode

OFF averaging time is approximately 0.1 second for 1300nm, or 0.2 second for 1550nm.

MINIMUM averaging time is approximately 3 seconds for 1300nm or 6 seconds for 1550nm.

MAXIMUM averaging time is approximately 51 seconds for 1300nm or 102 seconds for 1550nm.

Continuous-Sweep Mode (see SWEEP control for achieving this mode)

OFF produces a real-time display at approximately 10 sweeps per second. Continuous sweeping will time-out after approximately 10 minutes.

MINIMUM produces a real-time display with reduced noise. Continuous sweeping will time-out after approximately 10 minutes.

MAXIMUM produces a real-time display, continuous average, with up to 8,192 averages. To achieve maximum sampling in 1300nm takes approximately 13 minutes; 26 minutes for 1550nm. Continuous sweep will time-out automatically after achieving maximum sampling.

(4) **PULSE** (LONG, MEDIUM, SHORT)

Selects length of the optical pulse applied to the fiber being tested.

(5) **INDEX OF REFRACTION**

With this thumbwheel switch, distance readout can be calibrated to the exact index of refraction

1 Initiates a new sweep, at the selected degree of filtering.

of the fiber being tested.

(6) MODE (LOSS: MAN, AUTO, /km; DIST)

Mutually exclusive pushbuttons switch the LCD function from distance measurement to loss measurement. In the Distance mode, a vertical marker appears on the screen. In MODE LOSS (dB) MAN, a horizontal marker appears in place of the vertical marker.

(7) MARKER

A detented control. With the LCD readout in distance mode (DIST), this control moves a vertically oriented Distance Marker left and right across the screen. Minimum movement is 1/25 of a division , or one meter of distance, which ever requires greater movement across the screen. If this control is rotated rapidly, the speed of the Marker across the screen will "gearshift" to facilitate large movements.

When the LCD readout is in the manual loss mode (LOSS MAN), this control moves a horizontally oriented Loss Marker up and down between the top and bottom of the screen. Movement increment is 0.04 division, regardless of the dB/DIV setting. Clockwise rotation moves the marker upward.

When switching between Distance and Loss modes, the Distance Marker maintains its position on the waveform. The Loss Marker is always initialized to its 0dB (center screen) position when MODE LOSS (dB) MAN is selected.

(8) ← → POSITION [1]/MARKER ROTATION

In DIST: A detented control, which moves the instrument's "display window" along the fiber horizontally on one-major-division increments for any distance scale. Clockwise control rotation moves the signal to the right and causes decreasing distance readings. Limits of waveform movement are –25 meters at the left edge of the screen and a maximum of 107+km at the right edge of the screen (dependent on IR setting).

In MODE LOSS, MAN: Rotates the Marker[5] to facilitate loss measurements.

(9) **DIST/DIV** (METERS)[1]

Accurately calibrated in a 1-2-5 sequence for 1.499 refractive index.

When the DIST/DIV setting is changed, the instrument automatically moves the display window to bring the Distance Marker and its associated waveform point as close as possible to center screen.

(10) **↑ ↓ POSITION**

This is a multi-turn, non-detented control. It moves the waveform but does not move the (MAN) Loss Marker. Its range (on 5dB/DIV scale) is ±5 major divisions.

(11) **VERTICAL SCALE** (5, 1, or 0.25dB/DIV)

Mutually exclusive pushbuttons control the scale factor at which reflected signals are displayed.

(12) **0dB Set** (under bezel)

This single-turn screwdriver adjustment serves to offset the manual-loss Marker to allow setting it precisely to midscreen for a 0dB reading. The range of adjustment is approximately ±5 minor divisions.

(13) **RECORD**

Pushing this button causes the waveform on the screen to be reproduced on a plotter or chart if either the XY1 Output Module or Y-T Chart Recorder is installed. Please refer to the appropriate operator's manual for detailed instructions.

(14) **SWEEP**

Single-Sweep Mode

This pushbutton toggles in a start/stop fashion. Momentary contact initiates a new sweep at exist-

ing control settings if a sweep is not already in progress. If a sweep is in progress, momentary contact will halt that sweep. During a MIN or MAX FILTER sweep, all panel controls except RECORD are enabled (some will interrupt and restart the sweep).

Continuous-Sweep Mode (Real-Time)

If the SWEEP button is held down for three seconds, the instrument will enter the continuous sweep mode (real-time display). In this mode, waveforms will be acquired continuously. The continuous sweep mode terminates automatically after about 10 minutes (longer for maximum filtering; see FILTER MAXIMUM). The continuous sweep mode may also be manually terminated by pushing the sweep button.

(15) **WAVELENGTH** (1300nm/1550nm)

These are mutually exclusive pushbuttons for selecting either 1300nm or 1550nm.

(16) **GPIB** (INST ID/LOCAL)

Switches between LOCAL front panel control or GPIB (remote or programmed) control (see GPIB section for explanation of GPIB commands).

When the LOCAL button is pressed, an immediate command is sent to an HP7470A plotter. Response to the command is immediate. The LOCAL plot includes front panel settings, front panel headings, grid and grid labels, waveform, LCD MODE readout, Marker and operator title block.

When INST ID is pressed, the LCD displays the instrument I.D. When the button is released, plotting begins. The INST ID plot includes front panel settings, LCD MODE readout, grid labels, waveform, and Marker. This partial plot is used to plot a second waveform when the grid and labels have already been plotted.

When the GPIB REMOTE light is on, the front panel is inoperative. The LOCAL button returns front panel control to the operator.

(17) **Trace Rotation** (under bezel)

This screwdriver adjustment serves to align the trace horizontally.

Indicators

(18) **Liquid Crystal Display**

In READOUT MODE DIST, this LCD indicates whole meters from 0 to 107+km with no decimal. Distance indicated is from the rising edge of the outgoing pulse to the Distance Marker. Note: the outgoing pulse is actually the front-panel connector reflection.

In the LOSS READOUT MODE, this LCD indicates decibels (dB) of one-way fiber loss represented between the center of the screen and any other point on the screen. Two decimal places and + and – are displayed. Range –25.00 to +25.00. Positive readings are shown for downward movement of the Marker.

(19) **Power Indicator**

This light-emitting diode comes on with the power switch.

(20) **GPIB** (REMOTE Indicator)

This light-emitting diode comes on when the OF235 is under GPIB control.

(21) **WAVELENGTH** (1300nm/1550nm)

The LED above the appropriate pushbutton will light when that button has been depressed. These LEDs also flash during a sweep.

Connectors

(22) **OPTICAL OUTPUT** ⚠ Single fiber connector for 125 µm (outside diameter) fiber.

CAUTION

Keep the OPTICAL OUTPUT connector clean at all times. Dust and dirt will degrade the optical output power. Keep the connector capped when it is not being used.

(23) **GPIB** (Rear Panel)

The GPIB connector is located on the back panel for feeding commands to the OF235. A controller or plotter may be plugged into this connector (see Figure 3-2).

(24) **O dB Set**

Offsets Marker position.

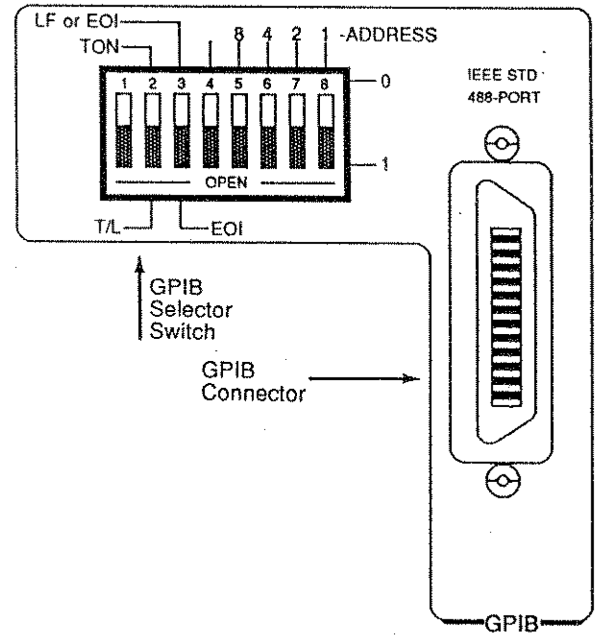


Figure 3-2. GPIB Connection.

Operational Check

This procedure checks instrument operating modes, functions, and basic performance without the use of test equipment. The procedure should satisfy most incoming inspection or preoperational checkout requirements. A detailed performance check that requires test equipment is part of the Calibration Procedure described in the Service Manual. This operational check will also familiarize you with the instrument.

Preliminary Procedure

Connect the Optical Fiber Interface Cable to the OPTICAL OUTPUT connector. The far end of the cable should be enclosed in its protective cover. Avoid exposure to the open end of the Interface Cable.

Set the front panel controls:

POWER	ON
FILTER	MIN
PULSE	LONG
READOUT MODE	DIST
VERTICAL SCALE	5dB/DIV
INDEX of REFRACTION	1.499
DIST/DIV	5000
WAVELENGTH	1300

NOTE:

The trace will appear on the CRT 40 seconds after the power has been turned on. This allows for stabilization of the display. Note that the LCD is counting down during this time.

Check Operation of Front-Panel Push-buttons and Controls

1. Rotate the INTENSITY control through its range, and note the change in brightness of the CRT beam.
2. Move the bottom of the displayed noise to the bottom graticule line with the ↑ ↓ POSITION control.
3. Position the Marker to the left edge of the screen. Then turn the ← → POSITION control clockwise until the LCD readout indicates 0.
4. Decrease the DIST/DIV setting to 50.
5. Increase the DIST/DIV setting through its entire range, and observe the waveform decrease in width and move to the left edge of the screen.

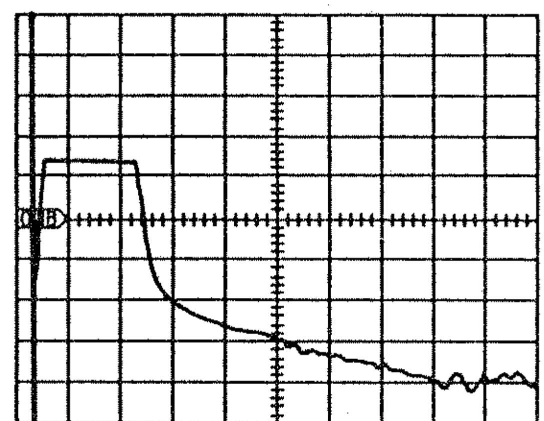


Fig. 3-3. Long Pulse Display.

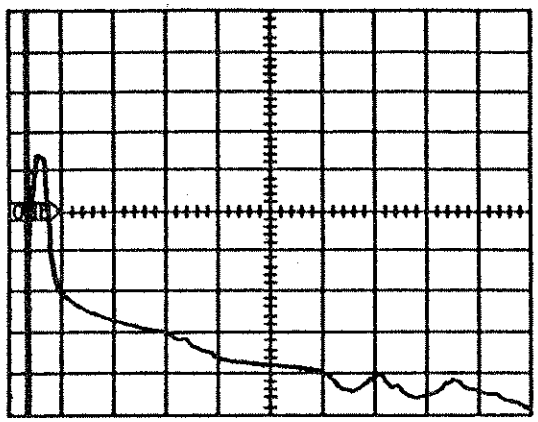


Fig. 3-4. Short Pulse Display.

6. Set the DIST/DIV to 200. The display should resemble that shown in Figure 3-3.
7. Push the FILTER OFF button. A new waveform is acquired without noise filtering.
8. Push FILTER MIN. A new waveform is acquired, and noise is reduced. Averaging time is approximately three seconds for 1300nm (six sec for 1550nm). The appropriate LED flashes during the time that the new waveform is acquired.
9. Push FILTER MAX. The noise on the new waveform is reduced even further. Averaging time is approximately 51 seconds for 1300nm (102 sec for 1550nm).
10. Switch FILTER back to MIN.
11. Push PULSE SHORT. The CRT display should resemble that in Figure 3-4.
12. Push PULSE MEDIUM. The waveform should appear approximately halfway between those seen in Figures 3-3 and 3-4.

13. Switch PULSE back to LONG.
14. Push the MODE LOSS (dB) MAN button. A horizontal line (Marker) appears at the center graticule line. If the Marker is slightly off, adjust it to coincide with the center graticule line using the 0dB SET control (under bezel).
15. Turn the MARKER control counterclockwise, until the Marker is on the bottom of the screen. The LCD readout should display +25.00.
16. Turn the MARKER control clockwise, until the Marker is at the top of the screen. The LCD readout should display –25.00.
17. Return the Marker to center screen (0.0).
18. Turn MARKER ROTATION to observe clockwise and counterclockwise rotation. (Marker rotates from the point where DIST Marker was last placed.)
19. Return to MODE DIST.
20. Move the Marker to the third major graticule.
21. Push MODE LOSS (dB) AUTO.
22. A rotated Marker will appear on the screen with two intensified zones on the trace. The Marker intersects the trace in the rightmost zone.
23. The vertical distance between the trace and Marker at the first zone (third major graticule) reads out on the LCD. This distance should equal the count of minor divisions between them.
24. Push DIST.
25. Move the Marker to the fourth graticule.
26. Push MODE LOSS (dB) /km.
27. A rotated Marker will appear at an intensified zone on the trace.
28. Use the ↑ ↓ POSITION control to intersect the Marker with the center vertical graticule at the bottom of the CRT.
29. The vertical distance from the baseline (bottom graticule) to the intersection of the Marker with the left edge of the screen equals the loss in dB/km. This

number will appear on the LCD readout.

30. Use the ↑ ↓ POSITION control to move the trace back up on the screen so the bottom of the noise is on the baseline.
31. Push FILTER OFF.
32. Push DIST.
33. Move the Marker to 0.
34. Set DIST/DIV to 5. The Marker is now on the vertical-center graticule line and coincides with the start of the pulse. The LCD readout should be 0.
35. Turn the MARKER control clockwise in one-step increments. The Marker should move one minor division per step. The LCD readout should count up in whole numbers from 0 to 25, one number per step.
36. With the Marker at the right edge of the screen, turn the ← → POSITION control counterclockwise. The waveform moves to the left, one major horizontal division per control increment. It takes five control increments to move a waveform point from the center to the left edge of the screen. The LCD readout increases from 25 to 50, five meters per control increment.
37. Set the DIST/DIV to 200; rotate the MARKER control clockwise to position the Marker at the center graticule line.
38. Set the DIST/DIV to 10, and adjust the MARKER control for a LCD reading of 1000.
39. Change the INDEX OF REFRACTION to 1.400, and watch the LCD readout increase to approximately 1070. The position of the Marker does not change.
40. Changing the INDEX OF REFRACTION to 1.599, should result in a reading of approximately 940.
41. Reset the INDEX OF REFRACTION to 1.499.
42. Increase the DIST/DIV setting to 500, and reposition the Marker for a readout of 0.
43. Decrease the DIST/DIV setting to 5. Push the VERTICAL SCALE 1dB/DIV button. The display will be magnified vertically.

44. Push the VERTICAL SCALE .25dB/DIV button. Note that the vertical magnification has increased again.

45. Set VERTICAL SCALE back to 5dB/DIV.

46. Hold the SWEEP button for three seconds. This will place the instrument in a continuous sweep mode (real-time display).

47. Push FILTER MIN. The real-time display will continue with reduced noise.

48. Push FILTER MAX. The display will continue to average (further reducing noise) for up to 25 minutes, or until the SWEEP button is pushed.

49. Momentarily depress SWEEP (<three seconds). The instrument will return to the idle mode.

50. Push FILTER MIN.

51. Switch the wavelength from 1300nm to 1550nm (if both are installed in this instrument). A new waveform will be acquired at the selected wavelength.

52. Depress the GPIB INST ID button and observe the GPIB adddress on the LCD readout (see Chapter 4, GPIB, for more information).

This concludes the operational check.

Using the OF235

Fiber Connector

The standard OF235 uses a high performance 3.5mm fiber connector manufactured by the Diamond Company. Options are available for a front-panel connector for AT&T Biconic (Option 20), FC (Option 22), NEC D4 (Option 23), Diamond 2.5 (Option 24), or Radiall (Option 25).

CAUTION

It is important to keep the OPTICAL OUTPUT connector and the connector plug clean at all times. Dust and dirt will affect the optical output power. The connector should be capped when not in use.

Connecting a Fiber to the OF235

Fibers to be tested may be connected to the OF235 in two ways: (1) directly, using a mating connector plug to match the front-panel connector, or (2) indirectly via an Optical Interface Cable, which may be obtained as an optional accessory.

NOTE: When connecting the Option 20 cable to the front-panel connector, it may be necessary to rotate the cable for optimum performance.

Setting Up the Fiber Display

After connecting a fiber to the OPTICAL OUTPUT connector, select 1300nm or 1550nm, then set the VERTICAL SCALE to 5dB/DIV, PULSE to LONG, and FILTER to MIN. Push READOUT MODE DIST. Increase the DIST/DIV setting, and turn the ← → POSITION control counterclockwise so that the entire fiber is displayed on the CRT. Set the bottom of the noise to the bottom of the screen with the ↑ ↓ POSITION control. These settings are a good starting point for an initial view of the fiber.

Figure 3-5 shows a sample display. The outgoing pulse is shown at the left side of the screen, followed by a gradually down-sloping trace called the backscattering signal. The backscattering signal is a weak reflection that occurs as the energy of the outgoing pulse travels down the fiber. The further the energy travels, the weaker the reflections appear due to the loss of the fiber. At the end of the fiber, a pulse appears.

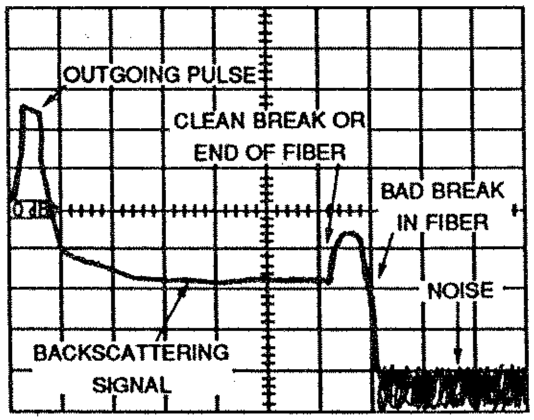


Fig. 3-5. Typical Fiber Display.

The height of the pulse indicating a break is dependent on the quality of the break and is no indication of the amount of loss in the fiber. Ragged breaks may not produce a pulse at all, but will show up only as a drop in the backscattering signal.

NOTE:

Mirror images (ghost echoes) may appear at multiples of the cable length whenever the cable length exceeds the pulse length. This is due to the highly polished ends of the fiber. If you see spikes at 1km, 2km, 3km, etc., when using a 1km cable, these are ghosts and not actual discontinuities. Note that you may also see a reflection of the end cap on some fibers.

A Closer View of Discontinuity

To see a close-up of a particular point in the fiber, set the Marker on this point, then decrease the DIST/DIV.

MIN or MAX filter may be used to decrease the noise on the trace and make the discontinuity stand out more clearly.

Also, if the change in the fiber is a small drop in the backscattering signal, the VERTICAL SCALE 1dB/DIV or 0.25dB/DIV may be used for magnification.

In some instances, PULSE MEDIUM or SHORT will provide better resolution in the backscattering signal. However, signal amplitude will be less than when PULSE LONG is used.

Use the ← → POSITION control to move the display window along the fiber in one-division steps.

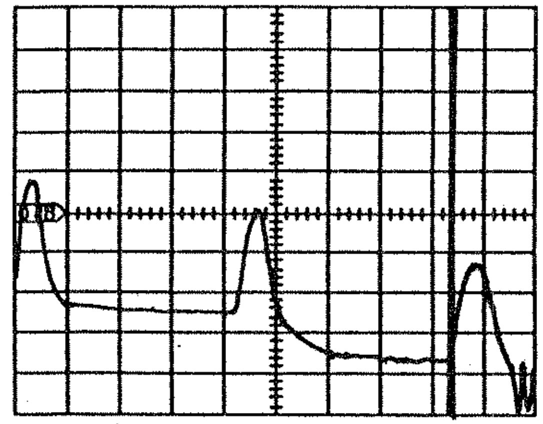


Fig. 3-6. Measuring Distance.

Measuring Distance

To measure the distance to a discontinuity, set the READOUT MODE to DIST (METERS).

Line up the Marker with the beginning of the discontinuity (the left edge of the reflected pulse, or the beginning of a drop in the backscattering signal) (see Figure 3-6). Decrease the DIST/DIV setting for more precise marker placement.

Distance from the instrument to the Marker is displayed on the LCD readout.

Distance Readout Calibration

Information on the index of refraction of the fiber is usually available from the fiber manufacturer. When the index of refraction is not known, set the IR control to 1.499.

When the propagation velocity is not known, and a precise measurement (better than 2%) must be made, the following calibration procedure can be used to adjust the INDEX OF REFRACTION control to the correct setting.

1. Connect a known length of fiber to the OPTICAL OUTPUT.
2. Measure the length of the fiber on the OF235. Adjust the INDEX OF REFRACTION control until the LCD readout corresponds to the known length of the fiber.
3. When 2% distance measurement accuracy is sufficient, set the INDEX OF REFRACTION control to 1.499.

Measuring Loss

MAN Measurements

To measure loss, move the Marker (DIST) to the point to be measured, then push the MODE LOSS (dB) MAN button. The Marker will center horizontally on the 0dB graticule line. Use the 0dB SET control (under bezel) to adjust the Marker exactly on the 0dB line.

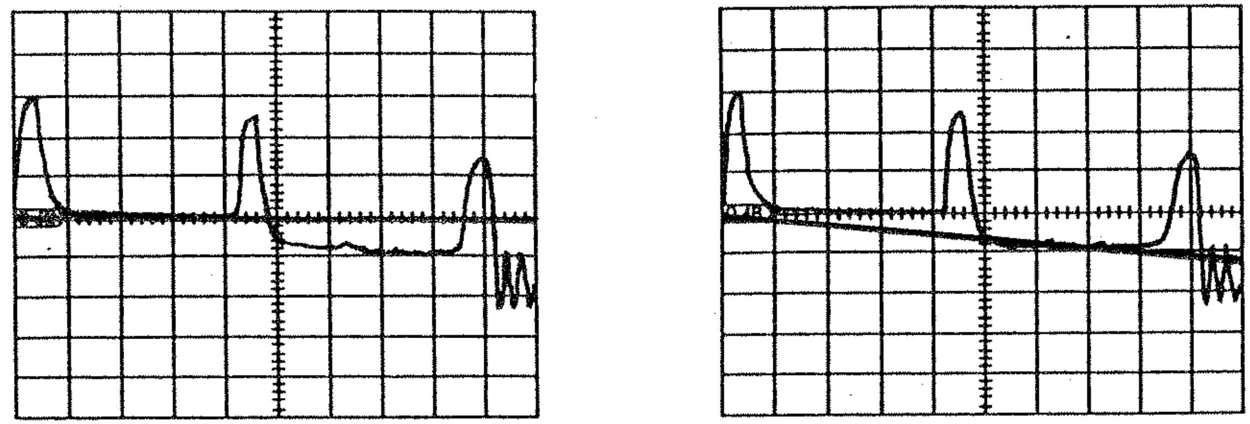


Fig. 3-7a and b. Measuring Loss.

Adjust the trace with the ↑ ↓ POSITION control so the point from which the loss measurement will be made is on the 0dB line (see Figure 3-7a).

VERTICAL SCALE 1dB/DIV or 0.25dB/DIV should be selected for small measurements. Use of FILTER MIN or MAX will reduce noise on the trace and make the measurement more accurate if the signal is weak.

Selecting PULSE SHORT instead of PULSE LONG sometimes results in better resolution in the backscattering signal. However, there is a drop in signal amplitude between these PULSE selections.

Turn MARKER ROTATION until the Marker coincides with the backscatter before the point to be measured.

Turn the MARKER control until the Marker is aligned with the backscatter after the point to be measured (MARKER ROTATION may need to be re-adjusted) (see Figure 3-7b). Read the difference in dB (between the two points) from the LCD readout.

Using this measurement technique, a difference of 1.0 indicates that 1.0dB of loss exists between the two selected points on the fiber.

Return the instrument to READOUT MODE DIST before attempting to move the display window to a new section of the fiber. This will make the Distance Marker visible, to facilitate the movement.

AUTO Measurements

Move the Marker (DIST) to the point to be measured, then push the MODE LOSS (dB) AUTO button. Two intensified zones will appear, one to the left of the Marker and one to the right. In approximately one second, a rotated Marker will appear, superimposed on the right zone and the LCD will display the calculated loss.

The instrument must be returned to MODE DIST to move the Marker for making the next measurement.

/km (slope) Measurements

Move the Marker (DIST) to the area to be measured. Push MODE LOSS (dB) /km. An intensified zone will replace the Marker. In approximately one second, a rotated cursor will appear through the intensified zone and the slope (dB/km) will be displayed on the LCD.

The instrument must be returned to MODE DIST to move the Marker for making the next measurement.

OF235 PROGRAMMING

Introduction to GPIB

IEEE Standard 488-1978 describes a general-purpose bus for instrument systems. The IEEE 488 bus is also known as the General Purpose Interface Bus (GPIB), which is what it is referred to in this manual.

The purpose of the GPIB is to provide an effective communications link over which messages can be carried between instruments in a clear and orderly manner. Instruments which are designed to operate according to the standard, as the OF235 is, can be connected to the bus and operated by a controller with the appropriate programming.

The GPIB System

The bus uses eight data and eight control lines. Information is transferred bit-parallel by an asynchronous handshake. This allows instruments with different transfer rates to operate together if they conform to the handshake state diagrams and other protocols defined in the IEEE standard.

A typical system (see Figure 4-1) could include a controller, such as the Tektronix 6130; a talker, such as a counter or digital multimeter; and a listener, such as a plotter or signal generator. More than one function can be combined in a single instrument.

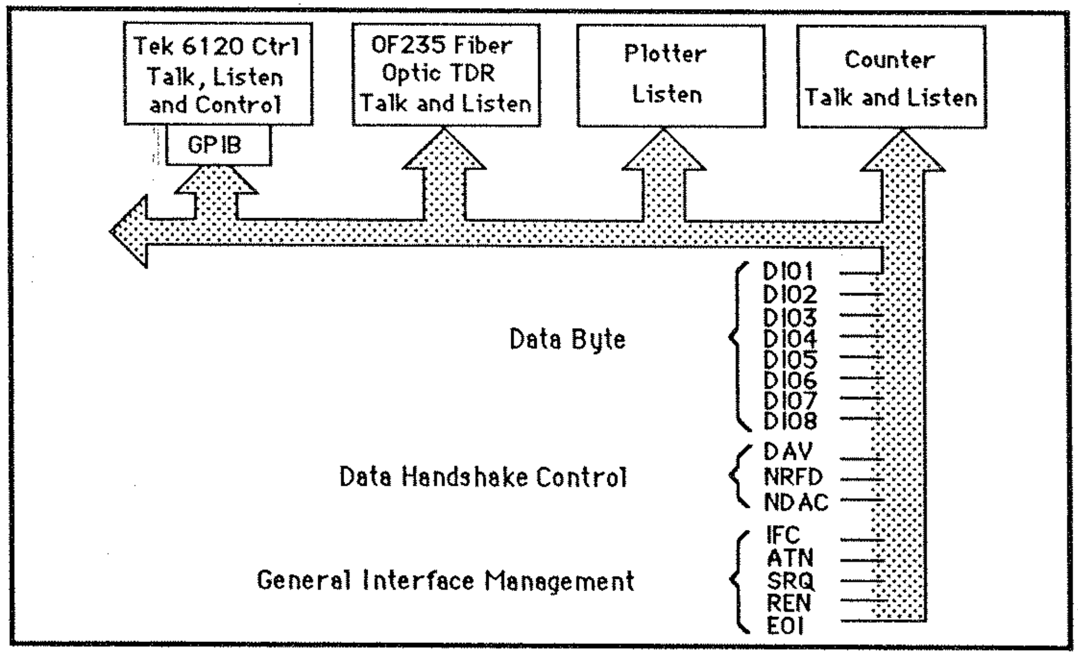


Fig. 4-1. GPIB (IEEE 488) System Showing Typical Instruments and Signal Lines.

For example, the Tektronix OF235 has both a listener/talker function and a talker-only function. Many instruments, including the OF235, also implement some or all of the other functions defined in the IEEE 488 standard which allow them to interrupt the normal sequence of events on the bus, report their status, or initiate a device function simultaneously with other devices on the bus. A complete list of the interface functions implemented in the OF235 is given later in this chapter.

Up to 15 devices, distributed over no more than 20 meters total cable length, can be connected to a single GPIB bus.

GPIB is a flexible system — it works in either a star or linear configuration (see Figure 4-2). To maintain the bus electrical characteristics, a device load must be connected for each two meters of cable, and one more than half the devices connected must be powered up (IEEE 488-1978).

Although devices are usually spaced no more than two meters apart, they can be separated farther if the required number of device-loads are lumped at any point. Also, if the system includes only the OF235 and a controller, they can be separated by four meters total cable length because each provides a device load.

Messages on the bus are interface messages or device-dependent messages. Interface messages are used to manage the interface functions of the instrument; they designate talkers and listeners. Device-dependent messages, however, are not used by the interfaces to change their state or configuration, but are passed on to the device functions of the instruments. Such messages can be data, such as a waveform acquired by the OF235, or remote-control messages, such as the setting of the OF235's wavelength parameter.

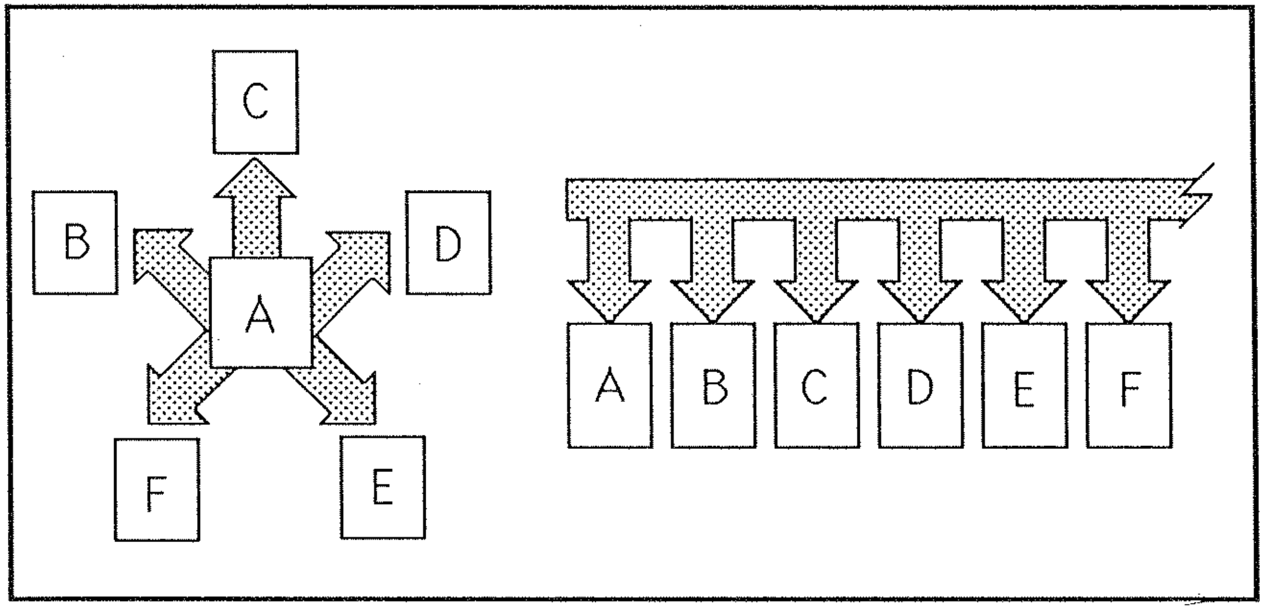


Fig. 4-2. Star and Linear Bus Configurations.

GPIB Bus Signal Lines

The GPIB bus contains three groups of signal lines: data, handshake, and control.

Eight lines, DIO1 through DIO8, are used to carry data (message) bytes on the bus.

The asynchronous, three-wire handshake is controlled by these lines:

DAV (Data Valid): asserted by the transmitting device

NRFD (Not Ready For Data): asserted by the receiving device

NDAC (No Data Accepted): asserted by the receiving device

Five interface lines are used for the control functions:

ATN (Attention): specifies how data on the DIO lines is to be interpreted — as interface messages when asserted or as device dependent messages when unasserted

IFC (Interface Clear): used to initialize the interface functions of all instruments and return control to the system controller

SRQ (Service Request): asserted to request service from the controller-in-charge

REN (Remote Enable): allows remote control of devices on the bus

EOI (End Or Identify): indicates the last byte of a message, or when asserted with ATN, polls devices connected to the bus.

See IEEE Standard 488-1978 (ANSI MC 1.1-1978), *IEEE Standard Digital Interface for Programmable Instrumentation* for full definition of these lines and protocol for their use. A brief discussion is presented here.

A Byte at a Time

The data and handshake lines are used for the source and acceptor handshake. Actually, they are two parts of the same handshake. Figure 4-3 shows the states of these lines as they are set by a talker using the source handshake and a listener using the acceptor handshake.

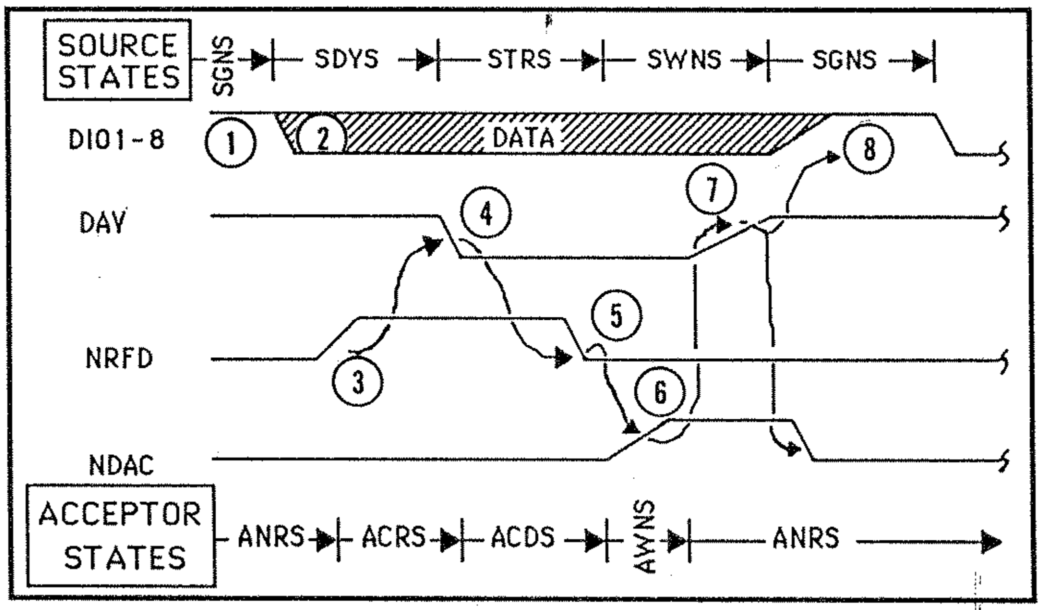


Fig. 4-3. Source and Acceptor Handshake States.

The timing diagram relates the electrical signals on the bus to the states of the source and acceptor handshakes. By looking at both, it may be easier to grasp the sequence of the interlocked handshakes than it is to absorb the state diagrams in the standard.

1. To begin, the source goes to the Source Generate State (SGNS). In this state, the source is not asserting a data byte on the data lines or DAV. When no bus driver is asserting a line, it rises to the high level set by the bus terminating network. The acceptors are in the Acceptor Not Ready State (ANRS), asserting both NRFD and NDAC. In this condition, NRFD and NDAC are low.

2. The source sets the data byte on the data lines and entering the Source Delay State (SDYS). If this is the last data byte in the message, the source may assert the EOI line at the same time. The source waits for the data to settle on the lines and for all acceptors to reach the Acceptor Ready State (ACRS).

3. Each acceptor says, "I'm ready" by releasing NRFD to move to ACRS. This is one of the points in the handshake designed to accomodate slower listeners. The NRFD line can be thought of as a wired-OR input to the source handshake logic. Any acceptor can delay the source handshake by asserting this line.

4. When the source sees NRFD high, it enters the Source Transfer State (STRS) by validating the data with DAV. The source then waits for the data to be accepted.

5. When the receiving devices see DAV low, they go to the Accept Data State (ACDS). Each device asserts NRFD because it is busy with the current data byte and is not ready for another.

6. As each device accepts the data, it releases NDAC to move from the ACDS to the Acceptor Wait for New cycle State (AWNS). Again, all receivers must release the NDAC line for the source to see a high level. When the source sees NDAC high (all have accepted the data), it enters the Source Wait for New cycle State (SWNS).

7. In the SWNS, the source can unassert DAV. This causes the acceptors to proceed to the ANRS, their initial state in the handshake. In ANRS they assert NDAC.

8. The source continues to the SGNS, its own initial state in the handshake. In this state, it can change the data lines to prepare a new byte for transmission.

This is a typical sequence. The exact sequence is defined by the state diagrams in the standard. The only requirement is that different sequences must still conform to the state diagrams.

Although the preceeding sequences involved a talker and listener(s), they are not the only ones allowed to use the handshakes. The source handshake is also used by the controller-in-charge to send system control messages.

These are called interface messages to distinguish from device-dependent messages sent from talkers to listeners (see Figure 4-4). The controller asserts ATN to get the attention of all devices on the bus and then uses the source handshake to send interface messages on the data lines.

The interface messages that constitute the controller's vocabulary are defined in the standard. They can be thought of as ASCII codes given new meaning when sent by the controller with ATN asserted.

Three groups of interface messages are reserved for the listen, talk, and secondary addresses. When a device sees its talk address (called My Talk Address) and ATN simultaneously, it must become a talker. When the controller removes ATN, the device begins the source handshake to transmit its data. Similarly, My Listen Address and ATN tell a device to listen to the data sent by a talker.

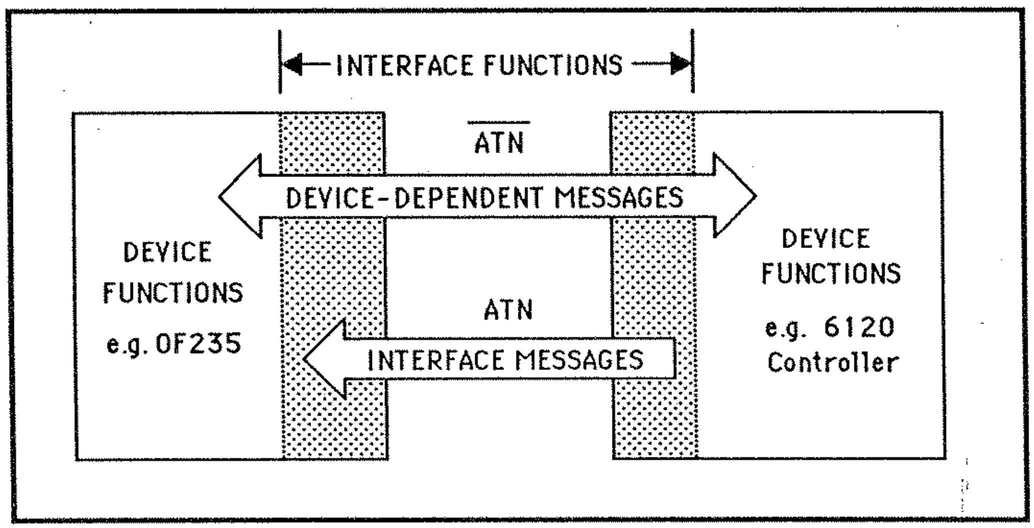


Fig. 4-4. Message Transferred from Talker to Listener.

The controller uses other kinds of interface messages for other tasks. The Serial Poll Enable (SPE) command used by the service request interface function. If an instrument is designed to assert SRQ when it has acquired data, the controller must poll the devices to find the interrupting device because any one (or more than one) can assert SRQ. To conduct the poll, the controller sends SPE, a universal command, then addresses each device in turn and reads a status byte from each. If the device asserted SRQ, it can code the status byte to tell the controller why.

Parallel Poll Configure (PPC) is an example of an addressed command. It prepares addressed devices to indicate who is requesting service. When ready, the devices respond together. A parallel poll is quicker, but more complicated than a serial poll. Parallel polling is not implemented in the OF235.

Device trigger is another function that uses an addressed command: Group Execute Trigger (GET). The OF235 GPIB capability includes a device trigger to cause a sweep. See the DT command later in this chapter for more details on using the Device Trigger function.

The controller issues the Device Clear (DCL) message to initialize internal functions of devices on the bus. A universal command, DCL, applies to all devices. Its effect on each instrument, however, is decided by the designer, who can choose to initialize any device function to any state that suits the purpose of the instrument. When the OF235 receives a DCL message, it resets its input and output buffers and resets the status byte (except power-up).

The interface messages are discussed in more detail later in this chapter.

OF235/GPIB Interface

The OF235 can be operated by remote control over the bus specified in IEEE Stanard 488-1978. This section describes the functional characteristics of the interface and its response to interface control messages. Because the interface is the link between the GPIB bus and the instrument, an understanding of the interface functions is necessary to effectively program the instrument.

The OF235 is fully programmable. All front-panel functions except power, intensity, and position can be controlled over the GPIB bus. Waveform data can be transmitted at the maximum rate allowed by the slowest listener. An internal Z80 microprocessor system makes the OF235 friendly. Commands are simple and mnemonic, simplifying the programming task.

GPIB Interface Function Subsets

IEEE Standard 488-1978 identifies the interface function repertoire of a device on the bus in terms of interface function subsets. These subsets are defined in the standard. The subsets that apply to the OF235 are shown in Table 4-1. How these functions are implemented is explained as part of the description of the commands used to program the OF235 and its response to interface control messages.

Addressing

The OF235 GPIB bus address is selected by a DIP switch on the back panel of the instrument (see Figure 4-5). GPIB addresses can be set over the full range allowed by the IEEE 488 standard: 32 to 62 (decimal) for My Listen Address (MLA) and 64 to 94 for My Talk Address (MTA). However, the values of the OF235 MLA and MTA are not independent of each other; they share the same lower five bits. For example, if the internal switches are set for a MLA of 33, MTA is set to 65.

Pressing the INST ID button on the front panel displays the instrument's primary address on the LCD display. To convert the displayed value to the actual primary address, add 32 (decimal) to the displayed value for MLA and 64 for MTA.

Table 4-1
OF235 Interface Functions

Function	Subset	Capability
Source	SH1	Complete
Acceptor Handshake	AH1	Complete
Service Request	SR1	Complete
Remote/Local	RL1	Complete
Parallel Poll	PP0	No responses to parallel poll
Device Clear	DC1	Complete
Device Trigger	DT1	Complete
Controller	C0	None
Talker	T5	Complete (GPIB address switch is not set to TON (see Figure 4-5))
	T3	Talker only (GPIB address switch is set to TON (see Figure 4-5)) No listener capability and no serial poll capability

Remote/Local Function

The remote/local function of the OF235 is controlled by the GPIB system controller and the front-panel LOCAL button. The instrument may have one of four states: local, remote, local with lockout, or remote with lockout.

Local

The OF235 powers up in local state. To return to local state from a remote state, one of the following must occur:

1. The LOCAL button is pressed (when not in remote lockout),
2. The remote enable line (REN) changes from asserted to unasserted, or
3. The instrument receives the GTL (Go To Local) message while addressed as a listener.

If the OF235 is executing a command, it waits until finished to return to local.

The instrument continues to process messages it receives over the bus while in local state, but it does not execute device-dependent commands that affect the state of the instrument or alter the state of data memory. If the instrument receives one of these commands, a 201 execution event message is issued.

Remote

The OF235 makes the local-to-remote state transition when it receives MLA with ATN and REN asserted.

When the OF235 enters the remote state, it lights the REMOTE LED, enters the last front-panel entry (if it was not yet entered) into the acquisition program, and leaves all operating parameters as set. Front-panel functions that affect the state of the instrument or data memory are disabled, with the exception of LOCAL, INTENSITY POSITION, and POWER. All front-panel functions that do not affect the state of the instrument or data memory (e.g., DISPLAY GPIB ADDRESS) remain operational.

Lockout

When the local lockout (LLO) interface message is received with ATN asserted, the OF235 enters the remote with lockout state, or the local with lockout state. There is no change in the condition of operating functions. The front panel operates the same as in remote state, except that the LOCAL button will not return the instrument to local control. Local with lockout state allows full local control of the OF235 and appears the same as local state to the operator. There is a difference to the programmer, however. When the OF235 receives MLA and ATN asserted in this state, it goes to remote with lockout state (assuming REN has not been unasserted) instead of simply going to remote state.

Response to Interface Control Messages

The OF235 does not respond to the following interface control messages:

1. **PPC:** Parallel Poll Configure
2. **PPU:** Parallel Poll Unconfigure
3. **TCT:** Take Control

The OF235 does respond to the following interface control messages as described:

GET (Group Execute Trigger): This message causes the OF235 to initiate a sweep if the DT SWEEP is set; otherwise it is ignored.

GTL (Go To Local): This message causes the instrument to go to the local state. The only commands that are executed in this state will be queries.

IFC (Interface Clear): This message resets the interface functions only, not operating modes. It has the same effect as sending the UNT (Untalk) and UNL (Unlisten) messages.

LLO (Local Lockout): If the OF235 is in remote state, LLO causes the instrument to lock out all front-panel controls that affect the state of the instrument or data memory, including the LOCAL button. If the OF235 is not in local state, the LLO

message causes the instrument to lock out front-panel controls when the instrument is set to remote state.

MLA (My Listen Address): The listen/talk address is set via the back-panel DIP switches (see Figure 4-5). When MLA is received, the listen function enters the listener addressed state. In this state, the instrument can accept commands from the GPIB.

MTA (My Talk Address): This message causes the talker function to enter the talker addressed state. In this state, the instrument sends any data previously requested. If no command was previously sent requesting data (i.e., a query command), the instrument responds by sending hexadecimal FF with EOI also asserted. This response (FF-EOI) is referred to as the talked-with-nothing-to-say message.

SDC, DCL (Selected Device Clear, Device Clear): Either of these messages reset the input and output buffers and reset the status byte (except power-up).

SPE, SPD (Serial Poll Enable, Serial Poll Disable): The OF235 has full serial poll capability (see instrument status description).

UNL (Unlisten): This message causes the listener function to enter its idle state (unaddressed). In the listener-idle state, the instrument cannot accept instrument commands from the GPIB.

UNT (Untalk): This message causes the talker function to enter its idle state. In the talker-idle state, the instrument cannot output data on the GPIB.

Remote Control Messages

The OF235 remote control messages are device-dependent messages on the GPIB bus. As such, they are not specified in the IEEE standard. Tektronix has developed a Codes and Formats Standard to enhance compatibility with other GPIB bus-interfaced instruments. To accomplish this, the standard specifies codes and syntax designed to be unambiguous, correspond to those used by similar devices, and be as simple and obvious as

possible. The OF235 conforms to this standard, making it easier for the programmer to write and understand the device-dependent code.

The OF235 responds to device-dependent messages that contain one or both of two types of commands: set commands and query commands. A set command causes the instrument to set an operating parameter or mode, or begin an acquisition. A query command causes the instrument to return the status of a specified operating parameter or function, or send waveform data over the GPIB.

Remote control messages are sent to the OF235 in ASCII and all responses from the instrument are in ASCII (waveform data may be requested in binary). The parity bit is ignored on input and set to zero on ASCII output. Lower- and upper-case are treated equally.

Input Buffering and Execution

All input to the OF235 is processed by the internal Z80 microprocessor. A remote control message begins when the OF235 is addressed as a listener, ATN is unasserted, and the transmitting device begins talking. The message ends when the message terminator is detected by the OF235. The Z80 buffers all messages it receives. It does not begin executing the commands until:

1. The input buffer becomes full, or

2. the message delimiter is received.

When either of these conditions occurs, the instrument sets bit 5 of the status byte, indicating that it is busy. It also asserts the NRFD bus line unless it is unlistened. As a result, no more messages can be sent until all the commands in the input buffer are executed. Then the busy status is reset and the instrument can continue to listen.

The OF235 executes input messages containing multiple commands one command at a time. Commands in a string are handled according to these rules:

1. If a command sets an operating parameter, further commands are not executed until the current command is completed.

2. If the instrument detects an error in a command, the input buffer is cleared and SRQ is asserted to report the error. The status byte is set to indicate an error condition. The exact type of error can be determined with the EVENT? query. Warning messages do not cause the input buffer to be cleared. The warning message is reported and command execution continues.

3. If a CURVE? query is received before the sweep is complete, the instrument waits until the sweep is complete before sending waveform data. During the wait period, the instrument reports waveform not readable status. The instrument may be assigned to talk during this period. However, instead of reporting the usual "talked with nothing to say" message (a single hex byte — FF), it begins talking as soon as the acquisition is complete.

4. When the instrument receives a command requesting output (i.e., a query command), it remains busy until the response to the last output command is placed in the output buffer. Further input is refused while the instrument is busy. If the OF235 is untalked while transmitting data, it waits to finish the transmission. The controller can interrupt and reset the talker function by sending the UNT message or addressing the OF235 as a listener. However, to reset the instrument's output buffer and clear the busy status, the controller must perform a device clear with the DCL or SDC interface messages.

5. Commands that require output (query) may be placed anywhere in the message string and multiple commands may be sent in a single message. Output from a single message is returned in a single message.

Command Syntax

Formats given for the set and query commands are intended as guides an are not intended to fully define the format. The following format symbols are used:

< > Indicates a defined element

... Follows an element or group of elements that may be repeated

The following delimiters are used to punctuate OF235 commands:

Delimiter	**Follows**
<space>	Header
<comma>	Argument
<semicolon>	Message unit (command)

When listening, the OF235 responds to either of two message delimiters:

1. The EOI line asserted concurrently with the last byte in the message whether data, a format character, or a lower-order delimiter (e.g., semicolon). This is the standard delimiter for Tektronix instruments.

2. The ASCII code for line feed (LF) sent as a byte following the message and any format character or lower-order delimiter. This is an alternate delimiter provided for compatibility with some instruments or controllers from other manufacturers.

The OF235 responds to either EOI or LF according to the position of the internal jumper (see Figure 4-5).

With EOI selected as the message terminator, any combination of format characters can be inserted at the beginning or end of a message or after a delimiter. Format characters are carriage return (CR), LF, or space.

Format characters can also be used with LF selected as the message terminator. However, the OF235 interprets LF as the end of the message; it holds up data transfer by asserting NRFD and executes all commands in the buffer before continuing to handshake data.

When talking, the OF235 uses EOI to delimit a message. It asserts the EOI line concurrently with the last byte in the message, normally the message unit delimiter (semicolon). However, if the internal jumper is set for LF (see Service Manual, 070-5743-00) as the message delimiter, the OF235 adds CR and LF beyond the normal end of the message (semicolon) and asserts EOI with LF. The OF235 does not source more data until retalked or serial polled. If the OF235 has no message to send when it is talked, it responds with a single data byte (hex value FF), all lines are asserted, along with EOI (when strapped for

EOI as the message delimiter). If the instrument is strapped for LF as the message delimiter, it sends FF, CR, and LF; EOI is asserted with the line feed.

Numbers

Numbers are assumed to be ASCII-coded decimal digits (except for waveform data). Only integer values are accepted.

Integers can be, signed or unsigned, the plus sign (+) is optional; the minus sign (-) mandatory. For example:

+127
–64
2048

Waveform Data I/O

Waveform data is output in binary or ASCII. Binary data enables greater throughput; it is moved in fewer bytes so data transfers require less bus time. ASCII data, on the other hand, is easier for many controller languages to read. A binary block has the following format:

%<BYTE COUNT>[<DATA BYTES>]<CHECKSUM>;

Where:

Preamble

% is the ASCII percent character.

BYTE COUNT is a 16-bit binary number sent in two bytes, most significant byte first. The value indicates the number of bytes that remain to be transmitted in the block, including the checksum, but not including the message delimiter (semicolon).

DATA BYTES are 16-bit binary data values in the range of 0 to 4096. The most significant byte is sent first.

CHECKSUM is an eight-bit, twos-complement binary number that is the modulo-256 sum of all preceding bytes in the block, excluding the % character.

Delimiter

; is the ASCII semicolon character.

Using the OF235 GPIB Feature

The commands that control the instrument from the GPIB are chosen for clarity of function. Where applicable, the commands relate directly to the front panel nomenclature. For example, sending PULSE SHORT is like pushing the SHORT button in the PULSE group on the front panel.

The units used are in meters and dB instead of DAC counts and delay counts. When you write a program to control the OF235, you will be able to use logical names and avoid continuously referencing the manual for command names and arguments.

Most front panel functions are accessable through the GPIB. The exceptions are those functions that are only useful if you are looking at the CRT (e.g., INTENSITY and POSITION). This gives you the greatest flexibility in using the OF235 in a variety of applications, from research and development to the manufacturing line.

There are several controls that relate directly to the GPIB function. These controls are located on the front panel and the back panel.

The front panel controls include an INST ID button, a LOCAL button, and a REMOTE light. These controls provide a method of communication between the instrument operator and the controller. When the instrument is in the remote state, the REMOTE light is on and the front panel controls are inoperative. The instrument operator gains control by pushing the LOCAL button, which will also cause the REMOTE light to turn off.

The instrument can be programmed to assert SRQ (service request) when the INST ID button is pushed. When the controller polls the instrument to determine the reason for the SRQ, the instrument informs the controller that the INST ID button was pushed (see USER command). The controller can then be programmed to take specific action when the INST ID button is pushed. For example, the instrument operator sets up the instrument until he gets the display he wants. He pushes the INST ID button to tell the controller to read the waveform. Note, however, that the controller must have been programmed to ask for a waveform on receipt of INST ID SRQ.

The INST ID button has another useful function. When it is pushed, the instrument's GPIB address is displayed on the LCD readout until the button is released. You can determine the instrument's address without resorting to decoding binary digits on the DIP switch on the back panel.

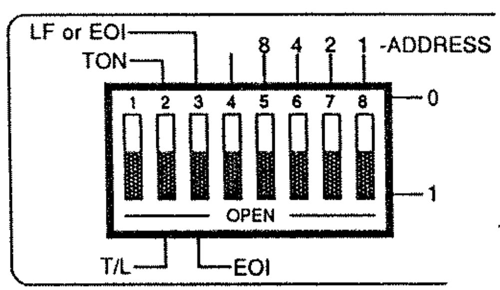


Fig. 4-5. Back-Panel DIP Switches.

Back Panel Switches

The controls on the back panel are for configuring the instrument to a particular GPIB environment. The controls are a series of DIP switches (see Figure 4-5) which set the instrument's GPIB address, the message unit delimeter, and the talker-only function.

The GPIB address is set using five binary coded DIP switches. Any address can be set from 0 to 30, with 31 taking the instrument off-line.

The message unit delimiter can be set to EOI or LF. When set to EOI a message will be delimited by EOI asserted concurrently with the last data byte. When set to LF a message will be delimited by a carriage return, line feed or an EOI asserted with the last data byte. This allows the instrument to be used with a variety of controllers.

The talker-only function allows the instrument to be connected to an HP 7470A plotter without the requirement that a controller also be connected. The GPIB address switches have no effect in this mode. When you want to send data to the plotter, push the LOCAL or INST ID button. The LOCAL button sends a complete plot to the plotter, including the grid labela, waveform and settings. The INST ID button sends a partial plot to the plotter, including the waveform and settings. This partial plot is used to plot a second waveform where the grid and labels are already plotted.

GPIB Command List for OF235

Following are the commands you send over the GPIB to control the OF235. All commands are sent as ASCII strings and follow Tektronix Codes and Formats conventions for headers, arguments, and delimiters. For ease in locating a command, they are listed here in alphabetical order. Boldface type in the syntax indicates the minimum characters which must be entered for any given command.

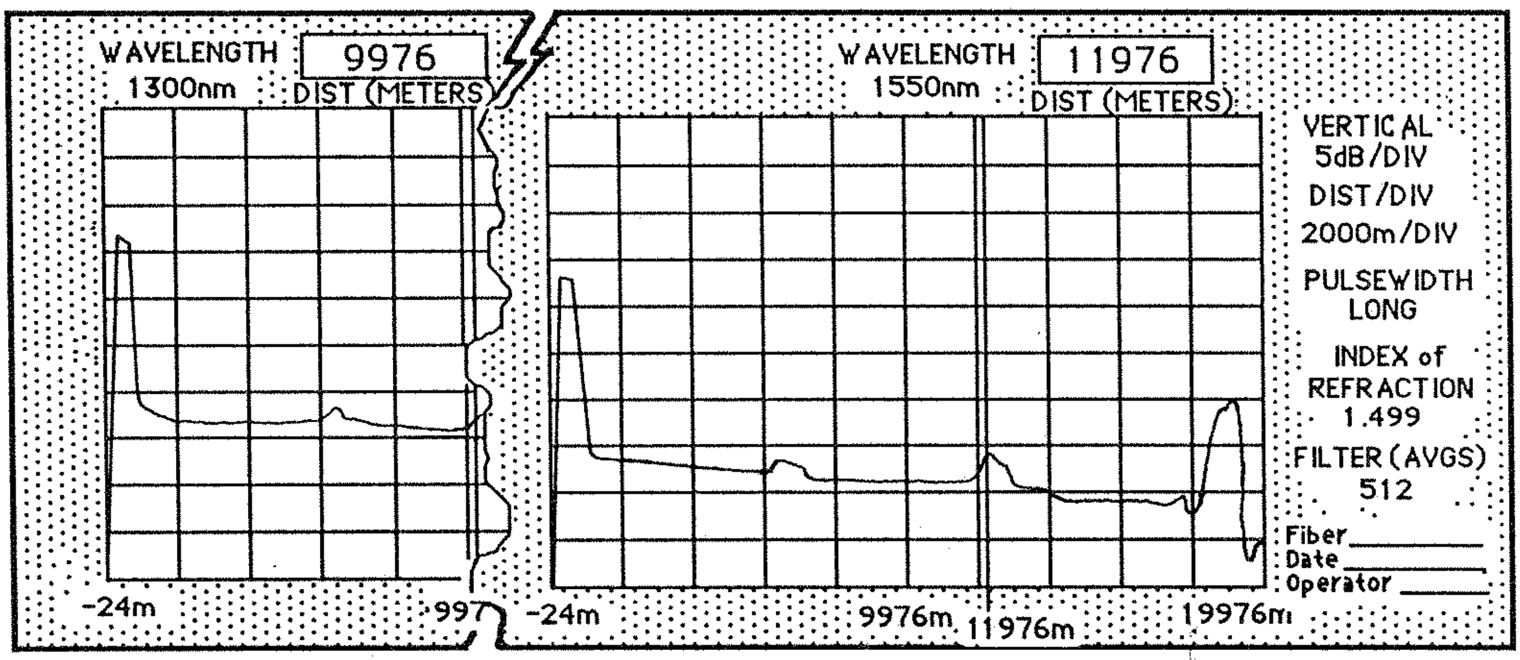


Fig. 4-6. Sample Plots.

AVGS (Number of waveforms averaged in a current waveform)

Query Syntax: **AVGS?;**

Query Response: AVGS <n>;

Discussion: The AVGS query returns the number of waveforms averaged in the current CURVE data. This gives you an idea of the quality of the waveform when the acquisition of a filtered waveform is stopped prematurely.

CURVE (Returns curve data)

Query Syntax:	**CURVE?;**
Query Response: (ASCII Format)	CURVE <n>,<n>,...,<n>;
Arguments: (ASCII Format)	<n> is an ASCII formatted decimal number between 0 and 50.00. Each number represents a waveform data point expressed in dB units. The 126 data points are separated by commas.
Query Response: (Binary Format)	CURVE %<byte count>data...<checksum>;
Arguments: (Binary Format)	The binary argument format consists of a percent sign followed by a 16-bit byte count, 126 16-bit data point values, an eight-bit checksum, and a semicolon. All 16-bit values are most-significant-byte-first. The **<byte count>** specifies the number of bytes following, up to, but not including, the <checksum>. The **data** contains the 126 data points expressed as 16-bit binary numbers between 0 and 4095. There are no delimiters between data points. The **<checksum>** is the 2's complement of the modulo 256 sum of the preceding binary data bytes and the binary count bytes, but not the percent sign (%) preceding the binary byte count.

Discussion: The CURVE query returns the curve data in the format specified in the ENCDG command. The ASCII formatted data is expressed in relative decibel units and the binary is expressed in fractions of decibel units. To convert a 16-bit binary data value to decibels, multiply by 0.0125. For additional information, see the ENCDG command.

DIST (Returns current distance to first data point)

Command Syntax: **DIST <n>;**

Arguments: <n> is an integer between -25 and 107,432*. Units are meters.

Examples: DIST 500;
DI -10;

Query Syntax: **DIST?;**

Query Response: DIST <n>;

Discussion: The DISTance command specifies where along the fiber that data acquisition is to begin. The OF235 is setup so that the stated distance is at the left of the screen, where possible. Otherwise, it will be placed as close as possible to the left of the screen and the SRQ line is asserted, warning you that the instrument is not at the requested setting.

*Maximum number is dependent upon the IR setting.

DT (Device Trigger function)

Command Syntax: **DT <argument>;**

Arguments:
OFF; Disables DT function; GET messages are ignored
SWEEP; Causes the instrument to start a sweep on receipt of a device trigger

Examples:
DT SWEEP;
DT S;
DT O;

Query Syntax: **DT?;**

Query Response: DT <argument>;

Discussion: The DT command specifies how the instrument is to react when a Group Execute Trigger (GET) is received from the controller. DT OFF ignores the GET. DT SWEEP causes a new sweep to start when GET is received.

DXDIV (Distance per Division setting)

Command Syntax: **DXDIV <n>;**

Arguments: <n> is one of the following integers: 5, 10, 20, 50, 100, 200, 500, 1000, 2000, or 5000.
Units are in meters per division (m/DIV).

Examples: DXDIV 500;
DX 2000;

Query Syntax: **DXDIV?;**

Query Response: DXDIV <argument>;

Discussion: Sets the instrument to the requested distance per division setting.

ENCDG (Sets data encoding)

Command Syntax:	ENCDG <argument>;	
Arguments:	ASCII;	Sets instrument to use ASCII format
	BINARY;	Sets instrument to use BINARY format
Examples:	ENCDG ASCII;	
	EN B;	
Query Syntax:	ENCDG?;	
Query Response:	ENCDG <argument>;	

Discussion: The ENCDG command establishes the format of future curve data output. The ASCII formatted data is expressed in relative decibel units and the binary is expressed in fractions of decibel units. To convert a 16-bit binary data value to decibels, multiply by 0.0125. For additional information, see the CURVE command.

ERR (Event Code)

Discussion: This is the older version of EVENT? and is included for compatibility with older Tek GPIB instruments.

EVENT (Event Code)

Query Syntax: **EVENT?;**

Query Response: EVENT <code number>;

Discussion: Event codes indicate a condition of which the instrument wishes to inform the controller. For example, error conditions, data acquisition complete, or the front panel ID button was pushed, will generate conditions that may cause the instrument to report an event. Event codes and their descriptions are listed at the end of this chapter.

FILTER (Filter setting)

Command Syntax: FILTER <argument>;

Arguments:

MAX;	Averages 512 waveforms
MIN;	Average 32 waveforms
OFF;	No waveform averaging

Examples:

FILTER MAX;
FILT MA
FIL MI
FI O

Query Syntax: FILTER?;

Query Response: FILT <argument>;

Discussion: The FILTER command sets the number of waveforms to average for each curve. The actual number of waveforms averaged in the curve data may not be the same as that set by the FILTER command. This occurs when the averaging is stopped prematurely by executing the STOP command, or by pushing the SWEEP button during the averaging process. The AVGS query is used to determine the actual number of waveforms averaged in the current curve data. If the averaging is allowed to complete, the number of averages will match the FILTER setting.

FP (Front-panel settings)

Query Syntax: **FP?;**

Query Response: FILT <n>;PULS <argument>;WAVL <n>; VERT <n>; DXD <n>; MODE <argument>;IR <n>;

Discussion: Returns the current physical front-panel settings. This gives the settings the instrument will go to when sent to LOCAL. The following settings are returned: FILT, PULSE, WAVLNGTH, VERT, DXDIV, MODE, IR

HELP (Returns list of valid command headers)

Query Syntax: HELP?;

Query Response: HELP ADDRess,AVgs,CUrve,DIstance,DT,DXdiv,EFm,ENcdg,ERror,EVent,FIlter,
FP,Help,ID,INit,IR,LCD,LCDRet,LOss,MARker,MATt,MDist,MOde,MSlope,Opc,Pulse,
RECord,RQS,SEt,STop,SWeep,TEST,User,VErtical,WAVFrm,WAVLength,WFmpre;

Discussion: The HELP query returns a list of valid headers.

ID (Returns instrument ID)

Query Syntax: **ID?;**

Query Response: ID TEK/OF235,V81.1,FVa.b;

Discussion: The ID query returns an instrument identification string. This string contains the instrument name and various version numbers as shown below:

V81.1	= Codes and Formats version
a	= OF235 System Firmware Version
b	= OF235 GPIB Firmware Version

INIT

Command Syntax: INIT;

Command Result: FILT OFF;PULS LONG;RQS OFF;DT OFF;DIST 0;WAVL 1300 (or installed laser);VERT 5; DXDIV 5000;MODE DIST;IR 1.499;MARK 0;ENCDG ASCI;USER OFF;WRI OFF;

Discussion: This is an operational command that causes the instrument to go to its default settings. The default settings for the OF235 are listed at the end of this chapter.

IR (Index of Refraction)

Command Syntax: **IR <n>;**

Arguments: <n> is a decimal number between 1.400 and 1.599

Examples: IR 1.400

Query Syntax: **IR?;**

Query Response: IR <n>;

Discussion: The IR command sets the index of refraction. The setting should match the optical fiber connected in order to obtain best measurement results.

LCD (Controller-to-operator signal)

Command Syntax: **LCD <n>;**

Example:

LCD 9999;
LCD 12;

Discussion: Where <n> is an integer between 0 and 9999. The integer will be displayed on the LCD readout until an LCDRET command is received. This provides a way for the controller to communicate with the operator.

LCDRET (Returns use of LCD readout to OTDR functions)

Command Syntax: **LCDRET;**

Example: LCDR

Discussion: The LCDRET command is used to restore use of the LCD display for measurement purposes after a previously executed LCD command.

LOSS (Loss Measurement value)

Query Synax: **LOSS?;**

Query Response: LOSS <n>;

Discussion: Returns the current loss measurement value in dB as read from the LCD readout. Note that when in /km mode, the readout shows loss/km. If the instrument is not in a loss mode, a settings conflict error (204) will be reported.

MARKER (Marker position setting)

Command Syntax: **MARKER <n>;**

Arguments: <n> is an integer between 0 and 250

Examples:
MARKER 100;
MARK 250;
MAR 0;

Query Syntax: **MARKER?;**

Query Response: MARK <n>;

Discussion: The MARKER command sets the Marker to the requested screen position. The argument 0 represents the left edge of the screen and 250 represents the right edge.

MATTACH (Data point to which Marker is attached)

Query Syntax: **MATTACH?;**

Query Response: MATT <n>;

Discussion: The MATTACH query returns the data point along the curve where the Marker is attached. For example, a response of "MATT 53;" specifies the attachment point of the Marker to be the 53rd data point.

In DIST mode the attach point is defined as the data point closest to the marker.

MDIST (Current position of distance Marker)

Command Syntax: **MDIST** <n>;

Arguments: <n> is an integer between 0 and 80000.

Examples: MDIST 1000;(Sets Marker at 1000 meters)
MD 13400;(Sets Marker at 13,400 meters)

Query Syntax: **MDIST?;**

Query Response: MDIST <n>;

Discussion: The MDIST command sets the Marker at the distance specified by the argument. If the requested distance is on the screen the Marker is moved to that position. Otherwise a new sweep is started with the distance set so the requested Marker distance is at center screen.

MODE (Mode setting)

Command Syntax:	**MODE <argument>;**	
Arguments:	AUTO;	Sets loss measurements to automatic mode
	DIST;	Sets mode to distance
	MANUAL;	Sets loss measurements to manual mode
	SLOPE;	Sets loss measurements to /km (slope) mode
Query Syntax:	**MODE?;**	Returns current loss mode setting.
Query Response:	**MODE** <n>;	

Discussion: The MODE command selects the operating mode of the instrument. The various modes of operation (listed in Arguments above) are discussed in detail in the Operator Section in this manual.

MSLOPE (Marker Slope)

Query Syntax: **MSLOPE?;**

Query Response: MSLOP <n>;

Discussion: Returns the Marker slope of the currently acquired waveform in dB/screen. The value returned is between –2E6 and +2E6, where 0 is horizontal. A marker rotating clockwise causes MSLOPE to increase toward +2E6, while a marker rotating counterclockwise causes MSLOPE to decrease toward -2E6.

OPC (Operation Complete)

Command Syntax: **OPC <argument>;**

Arguments: **OFF;**
ON;

Examples: OPC ON
O OF

Query Syntax: **OPC?;**

Query Response: OPC <argument>;

Discussion: The OPC ON command causes the instrument to assert SRQ when a waveform is readable. This allows building an interrupt-driven system when acquiring highly filtered (very slowly acquired) waveforms.

PULSE (Pulse Setting)

Command Syntax: PULSE <argument>;

Arguments:

LONG;	Sets optical pulse to 4μs
MEDIUM;	Sets optical pulse width to 1.5μs
SHORT;	Sets optical pulse width to 0.5μs

Examples:

PULSE LONG;
PUL MED;
P S;

Query Syntax: PULSE?;

Query Response: PULS <argument>;

Discussion: The PULSE command sets the laser pulse width. The possible widths are 0.5μs (50 meters), 1.5μs (150 meters), and 4μs (410 meters).

RECORD (Send record to chart recorder)

Command Syntax: **RECORD;**

Examples:

RECORD
RE

Discussion: Causes the current displayed waveform to be sent to the strip chart recorder.

RQS (Enable/disable Request for Service)

Command Syntax: **RQS <argument>;**

Arguments:

OFF;	Disables instrument from asserting SRQ
ON;	Enables the instrument to assert the SRQ line

Examples:

RQS ON
RQ OF

Query Syntax: **RQS?;**

Query Response: RQS <argument>;

Discussion: When RQS ON is executed, the instrument will assert the SRQ line when abnormal events occur, and on some normal events if requested. RQS OFF disables the instrument's RQ generating capabilities. It is recommended that RQS ON be used, providing the controller is able to handle SRQs. This enables optimum reporting of system events.

SET (Current instrument settings)

Query Syntax: **SET?;**

Query Response: SET <arguments>;

Discussion: Returns the current programmed settings of the instrument in a form that can be sent back to the instrument at a later time to restore the settings. The following settings are returned: DT, RQS, WAVL, FILT, DXD, VERT, PULSE, DIST, IR, MODE, MARK, USER, OPC, ENCDG

STOP (Stop waveform acquisition)

Command Syntax: STOP;

Examples: STOP;
ST;

Discussion: Stops the current waveform acquisition and makes the waveform available to be read with the CURVE? query. The actual number of waveforms averaged before the STOP command may be obtained by executing the AVGS? query.

SWEEP (Start a sweep)

Command Syntax: **SWEEP <argument>;**

Arguments:

CONTIN;	Causes repeated sweeps to occur.
SINGLE;	Causes a single sweep to occur.

Examples: SWEEP SINGLE
SW C

Query Syntax: SWEEP?;

Query Response: **SWEEP <argument>;**

Discussion: This is an operational command that causes the instrument to start a laser sweep and acquire data in its local memory.

TEST (Perform diagnostics)

Command Syntax: **TEST;**

Example: TEST;

Discussion: This is an operational command that causes the instrument to perform diagnostics and report any errors found. Note that curve data cannot be read while in continuous sweep; it must be stopped first.

USER (Enable/disable user interrupts)

Command Syntax: USER <argument>;

Arguments:

OFF;	Enables the user interrupt feature.
ON;	Disables the user interrupt feature.

Examples:

USER ON
U OF

Query Syntax: USER?;

Query Response: USER <argument>;

Discussion: When user interrupts are enabled (USER ON), an SRQ is asserted by the instrument when the INST ID button is pushed. The instrument returns 43 hex in the serial poll status byte and EVE 403 in response to EVENT?.

VERTICAL (Vertical scale setting)

Command Syntax: VERTICAL <argument>;

Arguments:

.25;	Sets the Vertical scale to 0.25 dB/DIV
1;	Sets the Vertical scale to 1 dB/DIV
5;	Sets the Vertical scale to 5 dB/DIV

Examples:

VERTICAL .25;
VERT 1;
VE 5;

Query Syntax: VERTICAL?;

Query Response: VERT <n>;

Discussion: The VERTICAL command selects the vertical scale setting.

WAVLNGTH (Wavelength of laser)

Command Syntax: **WAVLNGTH <n>;**

Examples:

WAVLNGTH 1300	Select 1300nm laser
WAVL 1550	Select 1550nm laser

Query Syntax: **WAVLNGTH?;**

Query Response: WAVL <n>;

Discussion: The WAVLNGTH command selects which laser should be used during future acquisitions. Attempting to select a laser that is not installed generates an execution error (EVENT 307).

WAVFRM (Returns preamble, followed by curve data)

Query Syntax: **WAVFRM?;**

Query Response: WAVF <preamble>;<curve data>;

Discussion: The WAVFRM query returns the preamble (as defined under the WFMPRE query), followed by the curve data (as defined in the CURVE query).

WFMPRE (Preamble)

Query Syntax: WFMPRE?;

Query Response:

WFMPRE ENCDG:ASC,XZERO:3500,XINCR:1.06;
WFMPRE ENCDG:BIN,XZERO:3500,XINCR:1.06,BYT/NR:2,BN.FMT:RP;

Discussion: Returns the preamble data which provides information about the properties of the curve (i.e., the encoding format of the data, the distance of the first data point and the distance between data points).

where:

ENCDG - The encoding format of the data (binary or ASCII)
XZERO - The distance to the first data point (in meters)
XINCR - The distance between data points (in meters)

Default (Power-on) Settings

Default settings for the OF235 are:

FILT	OFF
PULSE	LONG
RQS	ON
DT	OFF
DIST	0
WAVL	1300 (or installed laser, if only one)
VERT	5
DXDIV	5000
MODE	DIST
IR	1.499
MARKER	0
FORMAT	ASCII
USER	OFF
WRI	OFF

Sample Controller Programs

Following is a Talker/Listener program for Tektronix 4050-series controllers:

```
100 REM DM5010 Talker/Listener Program
110 REM DM5010 Primary Address = 16
120 INIT
130 ON SRQ THEN 260
140 DIM A$(200)
150 PRINT "Enter Message(s):";
160 INPUT C$
170 PRINT @16:C$
180 REM Check for queries
190 IF POS(C$,"?",1)=0 THEN 150
220 REM Input from device
230 INPUT @16:A$
240 PRINT A$
250 GO TO 150
260 REM Serial POLL Routine
270 POLL X,Y;16
280 PRINT "Status Byte: ";Y
290 RETURN
```

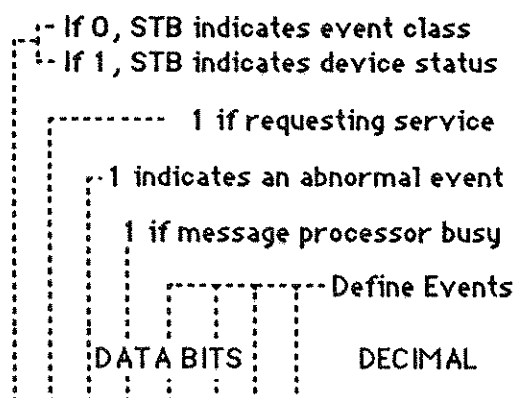
Following is a Talker/Listener program for Tektronix 4040-series controllers:

```
100 Rem DM5010 TALKER/LISTENER PROGRAM
110 Rem        PRIMARY ADDRESS = 16
120 Init all
130 On srq then gosub srqhdl
140 Enable srq
150 Dim respons$ to 200
160 Input prompt "ENTER MESSAGE(S): ":message$
170 Print #16:message$
180 Rem CHECK FOR QUERIES
190 If pos(message$,"?",1) then goto 280
260 Goto 160
270 Rem INPUT FROM DEVICE
280 Input #16:respons$
290 Print "RESPONSE: ";respons$

300 Goto 160
310 Rem SERIAL POLL ROUTINE
320 Srqhdl: poll stb,pri
330 Print "STATUS BYTE: ";stb
340 Resume
350 End
```

Status and Error Reporting

Through the Service Request function (defined in IEEE-488 Standard), the instrument may alert the controller that it needs service. This service request is also a means of indicating that an event (a change in status or an error) has occurred. To service a request, the controller performs a Serial Poll. In response, the instrument returns a Status Byte (STB), which indicates whether it was requesting service or not. The STB can also provide a limited amount of information about the request. The format of the information encoded in the STB is given in Figure 4-7.



Status Byte (Example)	8	7	6	5	4	3	2	1		Not Busy	Busy
Power On	0	1	0	X	0	0	0	1		65	81

Fig. 4-7. Definition of STB bits.

When data bit 8 is set, the STB conveys Device Status information that is indicated by bits 1 through 4. Bit 1 is set when the OF235 is acquiring data in continuous sweep. Bit 2 is set when acquiring data in a single sweep.

Because the STB conveys limited information about an event, the events are divided into classes. The STB reports the class. The classes of events are defined as follows:

COMMAND ERROR: Indicates the instrument has received a command that it cannot understand.

EXECUTION ERROR: Indicates that the instrument has received a command that it cannot execute. This is caused by arguments out of range or settings that conflict.

INTERNAL ERROR: Indicates that the instrument has detected a hardware condition or firmware problem that prevents operation.

SYSTEM EVENTS: Events that are common to instruments in a system (e.g., Power on, User Request, etc.).

INTERNAL WARNING: Indicates that the instrument has detected a problem. The instrument remains operational, but the problem should be corrected (e.g., out of calibration).

DEVICE STATUS: Device-dependent events.

The instrument can provide additional information about many of the events, particularly the errors reported in the Status Byte. After determining that the instrument requested service (by examining the STB), the controller may request the additional information by sending event query (EVENT?). In response, the instrument returns a code which defines the event.

Event Codes

The following are listings of events or errors which are returned by the EVENT? command:

Abnormal Events	Event Query Response	Serial Poll Response†	
		Decimal	Hex
Command Errors:			
Invalid command header	101	97	61
Header delimiter error	102	97	61
Argument error	103	97	61
Argument delimiter error	104	97	61
Non-numeric Argument	105	97	61
Missing argument	106	97	61
Invalid message unit delimiter	107	97	61
Binary block checksum	108		
Binary block byte count	109		

(con't next page)

Abnormal Events	Event Query Response	Serial Poll Response†	
Execution Errors:			
Remote-only command received while in local	201	98	62
Command aborted due to rfl	202	98	62
Both input & output buffers full	203	98	62
Settings conflict	204		
Argument out of range	205	98	62
Group Execute Trigger ignored	206	98	62
Required hardware not present	251	98	62
Internal Errors:			
Interrupt fault	301	99	63
System error	302	99	63
Illegal event code	303	99	63
OTDR-GPIB communication errors			
No reponse from system CPU	304	99	63
Interprocessor command error	305	99	63
Interprocessor parameter error	306	99	63
Interprocessor conflict	307	99	63
Interprocessor busy	308	99	63

†"Busy bit" off. If ON, add 16 hex.

Normal Events	Event Query Response	Serial Poll Response	
System Events:			
Power on	401	65	41
Operation complete	402	66	42
ID user request	403	67	43
Device-Dependent Status:			
Idle	0	128	80
Acquisition in process, contin sweep	0	129	81
Acquisition in process, single sweep	0	130	82

OPTIONS

The following are options which are available for the OF235 Fiber Optic TDR:

Option 1	**XY1 Output Module**: see Tektronix manual 070-4737-00.
Option 4	**Y-T Chart Recorder**: see Tektronix manual 070-5160-00.
Option 7	**Delete 1550nm wavelength.** This option provides for an instrument which has 1300nm wavelength only.
Option 8	**Delete 1300nm wavelength.** This option provides for an instrument which has 1550nm wavelength only.
Option 12	**Short Pulse of 0.2μs:** This option changes the SHORT PULSE displayed pulse length from 47 meters to 17 meters, ±1.2 meters. See Service Manual (070-5743-00) for information on changing pulse lengths.

Option 20 — **AT&T Biconic Connector**: changes the standard Diamond connector to an AT&T Biconic optical connector. This change allows the use of standard AT&T Biconic connectors at the OF235 front panel, eliminating the need for specially configured adapter cables.

Physical Changes: See Replaceable Parts Lists in the Service Manual (070-5743-00) for items marked (Option 20).

Option 22 — **FC Connector**: changes the standard Diamond connector to an FC optical connector. This change allows the use of standard FC connectors at the OF235 front panel, eliminating the need for specially configured adapter cables.

Physical Changes: See Replaceable Parts Lists in the Service Manual (070-5743-00) for items marked (Option 22).

Option 23 — **NEC D4 Connector**: changes the standard Diamond connector to a NEC D4 optical connector. This change allows the use of NEC D4 connectors at the OF235 front panel, eliminating the need for specially configured adapter cables.

Physical Changes: See Replaceable Parts Lists in the Service Manual (070-5743-00) for items marked (Option 23).

Option 24	**Diamond 2.5 Connector**: changes the standard Diamond connector to a Diamond 2.5 optical connector. This change allows the use of Diamond 2.5 connectors at the OF235 front panel, eliminating the need for specially configured adapter cables.
	Physical Changes: See Replaceable Parts Lists in the Service Manual (070-5743-00) for items marked (Option 24).
Option 25	**Radiall Connector**: changes the standard Diamond connector to a Radiall optical connector. This change allows the use of standard Radiall connectors at the OF235 front panel, eliminating the need for specially configured adapter cables.
	Physical Changes: See Replaceable Parts Lists in the Service Manual (070-5743-00) for items marked (Option 25).
Option A1	**Universal EURO**: 220V, 16A, 50Hz (161-0132-00)
Option A2	**United Kingdom**: 240V, 13A, 50Hz (161-0133-00)
Option A3	**Australian**: 240V, 15A, 50Hz (161-0135-00)
Option A4	**North American**: 240V, 15A, 60Hz (161-0134-00)
Option A5	**Switzerland**: 220V, 10A, 50Hz (161-0167-00)

ACCESSORIES

Standard Accessories

1	Operator Manual	070-5742-00
1	Blank Module	016-0782-00
1	AC Power Cord	161-0104-00
1	Battery Power Cord	161-0149-00
1	Optical Fiber Interface Cable (Standard only)	175-9695-00
1	Optical Fiber Interface Cable (Option 20 only)	175-9685-00
1	Optical Fiber Interface Cable (Option 22 only)	175-9774-00
1	Optical Fiber Interface Cable (Option 23 only)	175-9976-00
1	Optical Fiber Interface Cable (Option 24 only)	174-0058-00
1	Optical Fiber Interface Cable (Option 25 only)	174-0059-00
1	Spare Fuse (Standard)	159-0032-00
2	Spare Fuses (Options A1-A5 only)	159-0029-00

With the exception of the power cords, these items are stored in the OF235 cover.

Optional Accessories

C5C Camera	
C7 Camera	
XY1 Output Module	
Y-T Chart Recorder	016-0506-07
Service Manual	070-5743-00
Hard Case, Transit	016-0658-00
Soft Case	016-0659-00
CRT Visor	016-0653-00
Optical Fiber Interface Cable (Diamond to FC)	175-9707-00
Optical Fiber Interface Cable (Diamond to AT&T Biconic)	175-9708-00
Optical Fiber Interface Cable (Diamond to NEC D4)	175-9981-00
Optical Fiber Interface Cable (Diamond to Diamond 2.5)	174-0057-00
Optical Fiber Interface Cable (Diamond to Radiall)	174-0060-00
Elastomeric Splice, 1 each	131-4008-00
Elastomeric Splice, 10 each	131-4008-10

APPENDIX A

Using the OF235 with the HP7470 Plotter

Introduction

The OF235 is able to generate a hardcopy of the current data and settings via the HP7470, HP7475, or other compatible plotter. A plot is obtained by putting the instrument in the talk-only mode and connecting it to a plotter which is in the listen-only mode. When a plot is desired, it is then only necessary to push the LOCAL button on the front panel of the OF235. Total plotting time is 1.5 minutes.

Setup

To place the OF235 in the talk-only mode, set GPIB DIP switch #2 (on rear panel) to the TON position (zero). When the OF235 is in talk-only mode, the other switches are ignored, so their position is irrelevant. These switches are read during instrument initialization, so you must cycle the power switch after changing any GPIB switch setting.

The HP7470 or HP7475 plotter must be placed in listen-only mode. To do this (GPIB address must be 31), set all five DIP switches to the "1" position. The plotter power must be cycled after making changes to these switches.

Pen 1 of the plotter is used to label settings, distances, and draw the grid. Pen 2 is used to plot the 1550nm waveform, settings, and readings. Pen 4 is used to plot the 1300nm waveform, settings, and readings. If a two-pen plotter is used, the 1300nm data will also be plotted with pen 2.

The OF235 and the plotter must have a GPIB cable connecting them; all other devices that drive the GPIB lines must be removed. A controller is not needed, nor should it be connected during direct-plot operation (will cause improper operation if connected).

Creating the Plot

Once setup has been completed, you need only push the LOCAL button on the front of the OF235 to send the currently displayed waveform and settings to the plotter. The total plot time is 1.5 minutes, during which time the instrument may be used to make other measurements without affecting the original data.

The ↑ ↓ POSITION control on the OF235 has no effect on the plotter waveform. In 5dB/DIV scale, the plotted waveform will be shown with the noise placed at the bottom of the plot. In either 1dB/DIV or .25dB/DIV, the point at which the distance Marker crosses the waveform is placed at the center of the plot.

Interpreting the Plot

The plotted waveform is a very acurate representation of the data. The waveform is adjusted for the current index of refraction by adjusting the length of the waveform. By doing this, the horizontal divisions are acurately represented by the DIST/DIV setting. This allows for easy estimation of distances along the waveform. For IR

values less than 1.499, the waveform will be plotted past the right-most vertical division. For IR values greater than 1.499, the waveform will be plotted inside the right-most vertical division.

The distance Marker is plotted in all modes, even those where the Marker does not appear on the screen. The Marker distance is plotted below the Marker in the same color as the Marker.

In LOSS modes, the sloped Marker is also plotted and is attached to the waveform in the same position as the waveform on the screen.

The exception to this is the MAN mode, in which the waveform and the slope Marker are not attached. In this case, it is assumed that you placed the rotation point on the waveform at 0dB, rotated and moved the Marker from that point using the MARKER control. The plot is drawn to match the screen when these assumptions are correct.

All settings and calculations that appear on the front panel are shown on the plot. The LCD readout value is plotted in the rectangle above the waveform and the type of reading is shown below the rectangle. The filter setting is shown along with the actual number of waveforms averaged to make the plotted waveform. This is useful when the averaging was stopped before acquisition was completed (i.e., by pushing SWEEP during an acquisition).

Plotting Two Wavelengths on the Same Plot

The internal plot routine is designed to easily plot both wavelengths of the same fiber. Plotting the first wavelength is done as previously described. To plot the other wavelength, push the other WAVELENGTH button on the front panel of the OF235. If the fiber has a different IR at the new wavelength, reset the IR.

If you are using a two-pen plotter, change pen 2 to a different color. This will help in distinguishing the two plots.

NOTE:

The plotter paper should not be disturbed between plots or grid alignment may be inacurate.

Push the INST ID button and the new wavelength will begin plotting. The settings and readings will be plotted in such a manner that they will not over-write those of the previous wavelength.